

Amendments to the Drawings:

No amendments to the drawings.

REMARKS/ARGUMENTS

The addition of section "e" under claim #1, is to clearly differentiate this technology from that in Shindo, US 5587320, and McNelly, 6524848, both of which are based on In-Vessel composting systems. All of their claims reference In-Vessel composting systems.

My technology eliminates the cost and other limiting features of In-Vessel composting systems. In my system, the aeration can be based on aeration veins built into a composting pad, with the air being pulled down through the compost, being heated as it passes through the compost, and then that hot air is pulled through the aeration manifold, to the blower, with the heat exchanger in the aeration manifold, either before or after the blower.

There are important composting process management procedures which can not be readily achieved when the compost is enclosed in any sort of vessel. I hold the specifics of these procedures as *Trade Secrets*. The key as far as this patent application is concerned, is that both the Shindo & McNelly patents are based on **In-Vessel** composting systems and my technology does not require that the compost be in any sort of vessel, container or other form of enclosure, making my process a major improvement because it eliminated the cost and other limiting features of In-Vessel composting.

Attached are reviews of both the Shindo & McNelly patents with my notes..

Applicant respectfully requests that a timely Notice of Allowance be issued in this case.

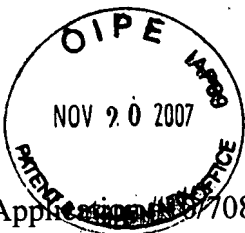
Respectfully submitted,

John A. Crockett

(845) 225-7763

Attachments

Attached are copies of the McNelly (6,524,848) & Shindo, et al, (5,587,320) patents with the lines numbered, and their references to their systems being based on **IN-Vessel** composting systems. End notes on both documents further show that the prior art in those systems is based on composting **In Vessels**.



Applicant: 6,524,848, John A. Crockett,

Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

See END Notes on Pages 13 & 14

United States Patent 6,524,848
McNelly, James
February 25, 2003
Recirculating composting system

Abstract

A recirculating composting apparatus cycles air and waste gases through a **composting vessel**, into a curing bin which contains previously composted material. Within the curing bin, ammonia and other noxious gases are adsorbed and converted into valuable fertilizer. The gases released from the curing bin may pass into another curing bin and then be recirculated back into the **composting vessel**, or may alternatively be released into the environment or passed through a biofilter. In preferred embodiments, **like containers may be used for each curing phase and also the composting phase. The use of similar or compatible containers allows an entire vessel to be converted from a composting vessel into a curing bin** simply by disconnection at one location and reconnection at a different location, without having to disturb the **contents within the vessel** or incur the undesired associated labor. Furthermore, resulting fertilizer products may be enriched with nutrients, have pH controlled, or be controlled to optimize various elements, gases, or heat during the curing phase, thereby simultaneously preventing a loss of nutrients and simultaneously increasing the economic value of the finished fertilizer.

Inventors:

McNelly, James J. (St. Cloud, MN)

Appl. No.:

09/960,830

Filed:

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435/290.1 ; 435/286.6; 71/11; 71/9

Current International Class:

C05F 17/00 (20060101); C05F 17/02 (20060101); C12M 001/00 (); C05F 011/08 ()

Field of Search:

435/286.6,290.1,290.2,290.3,290.4 71/9,11

References Cited [Referenced By]

U.S. Patent Documents

Application #10/708,254, John A. Crockett,
Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

3 4956002

4 September 1990

5 Egarian

6 5175106

7 December 1992

8 Laurenson, Jr.

9 5206173

0 April 1993

1 Finn

2 5459071

3 October 1995

4 Finn

5 5597732

6 January 1997

7 Bryan-Brown

8 Primary Examiner: Redding; David A.

9 Attorney, Agent or Firm: Watkins; Albert W.

0 Parent Case Text

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

This application claims the benefit of Provisional Application No. 60/234,962, filed Sep. 23, 2000.

Claims

I claim:

1. A gas recirculating **compost system, comprising: a closed aerobic compost vessel** with a gas inlet and a gas outlet; **a closed aerobic curing bin** having a gas inlet and a gas outlet operatively connected to send gas to said **compost vessel** gas inlet; and a **closed biofilter** having a gas inlet operatively connected to receive gas from said **compost vessel** gas outlet, and a gas outlet operatively connected to send gas to said **curing bin** gas inlet and a gas blower operatively connected to the system and constructed so as to recirculate a gas stream within the system.

2. The gas recirculation compost system of claim 1 wherein said gas blower recirculated the gas stream from the **compost vessel** through the biofilter to the curing bin and then returned to the compost vessel.

3. The gas recirculation compost system of claim 1 further comprising ports to introduce fresh air into the recirculation system to replenish consumed oxygen, and to vent waste gas from the system.

4. The gas recirculation compost system of claim 1 further comprising an additional biofilter and a monitor for monitoring and control of the gas stream.

5. A method for biologically processing source materials into agriculturally beneficial fertilizer, comprising the steps of: recirculating air and waste gases through a **compost vessel**, a biofilter and a curing bin and back to the **compost bin**; monitoring characteristics and composition of the gases; and controlling the system in accordance with said monitoring.

6. The method of claim 5 further comprising the steps of: composting said source material to produce composted source material; transferring said composted source material to said **curing bin**; curing said composted source material to produce cured material; transferring said cured material to said biofilter; and biofiltering said air and waste gases with said cured material.

7. The method of claim 5 further comprising the steps of: composting said source material in said **compost vessel** to produce composted source material; transferring said **compost vessel** to a **curing bin** connection and operatively connecting said **compost vessel** within said recirculating air and waste gases; curing said composted source material in said **compost vessel** to produce

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1 cured material; transferring said **compost vessel** to a biofilter connection and operatively
2 connecting said **compost vessel** with said recirculating air and waste gases; and biofiltering said
3 air and waste gases with said cured material.

4 8. The gas recirculation compost system of claim 4 further comprising means for controlling the
5 nitrogen content within said closed aerobic **curing bin**.

6 9. The gas recirculation compost system of claim 4 further comprising means for controlling the
7 pH within said **closed aerobic curing bin**.

8 10. The gas recirculation compost system of claim 4 further comprising means for controlling the
9 carbon dioxide content within said **closed aerobic curing bin**.

10 Description

11 BACKGROUND OF THE INVENTION

12 1. Field of the Invention

13 The present invention pertains generally to a composting system for biologically converting
14 diverse and potentially hazardous source materials into safe and agriculturally beneficial soil
15 amendments and fertilizers. More particularly, **the invention comprises an array of enclosed**
16 **containers**¹ which perform the various steps of composting, curing and biofiltration, and which
17 provide only limited, controlled exchange of gases and liquids into the environment during the
18 biological conversion process. In an even more specific embodiment, the source materials are
19 first composted, then cured, and finally serve as biofiltration media in a closed-loop system.
100 Gases are recirculated from compost through curing and biofiltration and back into the compost,
101 while temperature and gas content within the closed loop are carefully regulated.

102 2. Description of the Related Art

103 Before about 1970, composting was typically a simple process in which waste materials were
104 piled and allowed to sit until they decomposed. It was most frequently done on a small scale and
105 was not often considered for industrial-scale problems. The ingredients placed into these piles
106 were poorly controlled, and the resulting mixture would decompose unpredictably, frequently
107 anaerobically, with strong odors associated therewith. Unfortunately, often the strength of these
108 odors were in direct correlation to the loss of valuable fertilizer components such as nitrogen.
109 Vermin were also often attracted to these piles, creating hazardous vectors for transmission of

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110 disease.

111 An advance in composting technology came from the realization that adding air to the
112 composting mixture could increase the efficiency of composting. The microbes that produce
113 more desirable fertilizer require air, and will smother inside of a static unaerated pile. Hence, the
114 initial methods of aeration involved moving or agitating the compost to allow air into the stack.
115 This method only partially satisfies the need for aeration, and consequently only poorly addresses
116 odors and nutrient loss, and does nothing to limit access by vermin. composting mixture could
117 increase the efficiency of composting. The microbes that produce more desirable fertilizer require
118 air, and will smother inside of a static unaerated pile. Hence, the initial methods of aeration
119 involved moving or agitating the compost to allow air into the stack. This method only partially
120 satisfies the need for aeration, and consequently only poorly addresses odors and nutrient loss,
121 and does nothing to limit access by vermin.

122 A typical example of this aeration is a windrow turner that picks up the compost and dumps it to
123 one side. Most municipal composting sites are currently windrow turner operations, though
124 process control is, unfortunately, quite primitive. Piles are typically turned at the convenience of
125 the operator, rather than to optimize the composting process. A typical pile of compost will use
126 all of its oxygen within about one-half hour, so such windrow turning is seldom related to actual
127 oxygen demand. Turning is done seldom enough that microbes in the center of the pile are
128 rapidly depleted, and the center of the pile stops composting. Turning the pile merely
129 re-inoculates the center material with fresh microbes, and composting continues in the center of
130 the pile for another one-half hour when the oxygen supply is, once again, depleted.
131 Unfortunately, the repeated mechanical actions that are required for turning destroy some
132 beneficial fungi that rely on large, filamentous growth. In addition to the oxygen and mechanical
133 problems introduced by a windrow system, composting with windrow turners is typically done in
134 an open, unsheltered area. The vagaries of weather and rainfall most often determine the water
135 content of the composting mass. When there is too little rain, the pile is too dry. When there is
136 too much rain, the pile is wet and requires frequent turning. Too much rain can also lead to
137 problems with runoff of leachate. During the loss of leachate there will not only be a loss of
138 fertilizer value but also a potential hazardous contamination of surrounding surface water and
139 soil. In the open, of course, it is also very difficult to control access by vermin.

140 One method used to overcome some of the disadvantages of pile composting is to enclose
141 compost piles in a building. An enclosure that keeps rain off of the compost allows better
142 regulation of water content. However, such a facility is very expensive. Furthermore, with pile
143 composting, various irritating and potentially toxic gases are sometimes produced. Since
144 operators must enter the enclosure to maintain the composting process, enclosing compost also
145 involves maintaining the quality of large volumes of air within the building. Without high-quality
146 and high-quantity air handling systems, the atmosphere within an enclosure can be irritating, if

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not toxic, to an operator. Sadly, with the removal of air in the building is a removal of nutrients from the compost. Consequently, the resulting compost is little better in fertilizer value than the compost of the open windows and piles. These enclosed buildings do, however, help to control or prevent access to the compost by most vermin.

Some of the disadvantages of pile composting are overcome by more **modern reactor vessel processes**. By design, the reactor vessel is typically only slightly larger than the compost which it contains. This reduces the land area required to store the compost during the composting process. In addition to reduced land area, the total volume containing or enclosing the compost is also reduced. Lower total volume means reduced air handling requirements. Furthermore, **in-vessel reactors also provide the opportunity for collection of potentially odorous emissions**. The compost is enclosed, and exhaust air may be routed through a filtration system. This separation of operator from compost air benefits the health and safety of all operators. There are other benefits, beyond land space and air handling, from **reactor vessels**. Handling and mixing, which is required in all systems, can also be mechanized using **reactor vessels**, and the compost is enclosed.

Unfortunately, **vessel systems** to date are complicated systems which require precision construction techniques and permanent, stable foundations. This necessarily drives the cost of present **reactor vessels systems** to levels even higher than required for building-type enclosures. In exemplary prior art systems, organic waste is fed into an opening at one end of the reactor and compost is removed from the other end. The material is moved through the reactor by, for example, a complex moving floor apparatus or hydraulic ram. **Aeration is sometimes provided by pressurized air forced through the organic waste from air vents located throughout the moving apparatus.**

Some **in-vessel systems** also include mixing systems, typically rotating paddles or prongs, within the compost mass. **Other in-vessel systems are static**. The agitation systems used with **in-vessel systems** are expensive, prone to wear and failure, and provide agitation at intervals that are not readily controlled with respect to the progress of the composting process.

Even in the advanced **in-vessel systems**, there is still a limitation of the composting systems that must be addressed for wider acceptance in the marketplace. During the composting process, even in highly controlled **in-vessel systems**, there will always be a potential for generation of significant quantities of undesirable and odorous gases such as ammonia. Some artisans have reduced the levels of emissions of these gases through very careful measuring and control of the source materials which are undergoing biological transformation, but this control adds expense and undesirably limits the application of the composting system to only a very few applications. Other artisans have attempted to filter out of the gas stream the undesired contaminant gases.

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Various gas filtration devices have been proposed and implemented, including chemical scrubbers and biofilters. Chemical scrubbers tend to be quite expensive to operate, but more importantly produce new wastes that must be disposed of. This generation of secondary wastes tends to be very counterproductive. Furthermore, the waste removed in the form of contaminated gas or chemical scrubbers and filters represents a permanent loss of valuable soil nutrients.

Biofilters have more recently gained acceptance in treating odors from a diverse range of sources. These biofilters contain any of a fairly wide variety of substrate materials which support living organisms in an aqueous phase upon the surface of the substrate. These organisms feed upon the contaminants in the gas stream, and digest these contaminants into more basic and harmless components, such as carbon dioxide and water. While the substrate materials will only infrequently need replaced, they also may be used directly as an agricultural amendment of value and benefit. Consequently, a biofilter does not produce a second waste stream, but instead produces beneficial product for use in agriculture.

While biofiltration has enabled a compost facility to eliminate any secondary solid waste production, there has heretofore been very little control or regulation over the release of gases into the atmosphere. During rapid composting, it is possible to overload a biofilter with excessive levels of ammonia. Additionally, when source materials are introduced into the compost that are higher in nitrogen content than expected or for which the biofilter was designed, there will similarly be a surge in ammonia production. This surge can, on occasion, saturate the biofilter and lead to a release of undesirable levels of ammonia or other compounds into the environment. This not only presents an odor control problem, but also represents a loss of valuable nitrogen which would otherwise be most desirable for fertilizers used commonly with agricultural application. There is, therefore, a need to provide better control over the gases released from a compost system, while simultaneously allowing the compost system to handle a wider variety of source materials with less operator intervention.

SUMMARY OF THE INVENTION

In a first manifestation, **the invention is a recirculating compost system having a closed aerobic compost vessel** with a gas inlet and a gas outlet, **a closed aerobic curing bin** having a gas inlet and a gas outlet, and a closed biofilter having a gas inlet and a gas outlet. A gas stream is recirculated from the **compost vessel** through the biofilter to the curing bin and returned to the **compost vessel**. Ports are provided to introduce fresh air into the recirculation to replenish consumed oxygen, and to vent waste gas from the system. Additional biofiltration and monitoring are also available for further monitoring and control over the waste gas.

In a second manifestation, the invention is a method for biologically processing source materials

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into an agriculturally beneficial fertilizer. The steps include the recirculation of air and waste gases through a **compost vessel**, a biofilter and a **curing bin**. Various characteristics and composition of the gases are monitored and the system controlled in accordance therewith. The source material is cycled through the system from a **compost vessel to a curing bin** and finally to the biofilter. Additional controls and measurements are contemplated herein which enable the production of a fertilizer of consistent composition.

OBJECTS OF THE INVENTION

A first object of the present invention is to reduce the undesired loss of valuable soil nutrients from a composting system, and to consequently yield a higher value fertilizer than was heretofore possible. A second object of the invention is to enable precise measurement and control over the amount of contaminants released into the environment. A third object of the invention is to lower the cost of operation of a composting system, to make the system more economically attractive in the marketplace. Another object of the invention is to make a compost system more tolerant of variations in source material. A further object of the invention is to reduce the amount of operator intervention required to operate a compost system. Yet another object of the invention is to limit the type of intervention required, so that less technical training is required for an operator to successfully operate a compost system. These and other objects of the invention are achieved in the preferred embodiment, which will be best understood when considered in conjunction with the appended drawing figures.²

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates the preferred embodiment compost system schematically, constructed in accord with the teachings of the present invention.

FIG. 2 illustrates the preferred embodiment compost system of FIG. 1 diagrammatically from a top plan view.

DESCRIPTION OF THE PREFERRED EMBODIMENT

A preferred recirculating compost system will include a **compost vessel** Co, a first curing bin Cu1, and a second curing bin Cu2. The exact structure or construction of **compost vessel** Co, **curing bin** Cu1 and **curing bin** Cu2 are not critical to the operation of the invention. One suitable physical construction for these bins is illustrated in my published international application WO 00/26337 published May 11, 2000, though there are many other **vessels** known in the art which will perform satisfactorily in accord with the present teachings.

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Compost vessel Co is filled with a source material as is known in the art, and the biological processes that produce compost are initiated. Most preferably, in terms of both cost of operation and quality of finished product, the composting will occur at a temperature of approximately 140 degrees Fahrenheit. Air is introduced into **compost vessel** Co and serves as a source of oxygen, which is vital for aerobic digestion of the source material. During the composting process, a number of waste gases are produced that may include ammonia, though the present disclosure is understood to not be solely limited to these or any other set or combination of waste gases.

The gases which are exhausted from **compost vessel** Co are passed through a heat exchanger³, where the gas will be cooled from the approximately 140 degrees Fahrenheit to approximately 70-108 degrees Fahrenheit. Some moisture will condense in the heat exchanger, and this moisture may be collected for further use in the system or may be released in the environment, depending upon the system and goals of the designer.

After leaving the heat exchanger, the gas is then passed into curing bin Cu2. Curing bin Cu2 will most preferably contain cured compost. Curing bin Cu2 then serves as a biofiltration device, extracting ammonia and other contaminants from the gas stream and biologically transforming these contaminants into harmless carbon dioxide, water, plant nutrients and other biologically compatible compounds. It is noteworthy here that curing bin Cu2 is not only continuing the usual curing process known in the art, but is also simultaneously being directly enriched in fertilizer value by the ammonia which is being extracted from the gas stream.

After leaving curing bin Cu2, the gases are quite similar to any ordinary air stream. The moisture and carbon dioxide levels will of course be elevated, but otherwise during normal operation this gas stream will be quite compatible with ambient air. In many ways, including elevated moisture and carbon dioxide, this air stream will closely resemble the air which a person breathes out. These components are, after all, produced using naturally occurring organisms. At this juncture then, it is quite possible to directly vent the gas stream to the atmosphere. This will be accomplished by passing the gas stream through valve 1 to the outlet, where it may be mixed directly with ambient air. It is conceivable that there may be occasion or source materials which place an extraordinary load upon curing bin Cu2, or where any release of contaminants is undesirable, even when curing bin Cu2 fails to adequately filter the gas stream or when curing bin Cu2 is removed for servicing. In these cases, it may be desired to add a second biofilter BF to the output, and switch valve 1 to pass the output stream through biofilter BF before releases to the ambient. In other instances, it may be desirable to diffuse the waste gas into the ambient, which will reduce problems such as condensation or frost accumulation in colder climates, for example. In such cases, which will readily be determined by those skilled in the art, a diffuser may be provided as illustrated in FIG. 1 and connected selectively through valve 1. As will be apparent, the exact configuration of the output from the preferred compost system is not critical,

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and may be adapted to a number of different possible configurations. Even valve 1 may be removed, and the output passed directly through either diffuser or biofilter BF, or released directly to the environment.

In practice, most of the gas from curing bin Cu2 will be recirculated to curing bin Cu1. Curing bin Cu1 is most preferably filled with composted material such as maybe taken from compost vessel Co after completion of a compost cycle. Most preferably, this material will have passed through the substantial part of the exothermic stage of composting, and would otherwise have been ready for storage in a typical prior art curing bin or curing pile. The gas circulation through curing bin Cu1 provides an adequate supply of oxygen thereto, ensuring continued development of a favorable product from the present composting system. In addition, in the event of a short-term overload of curing bin Cu2 caused by excess production of ammonia or the like from compost vessel Co, there will still be adsorption and conversion of the ammonia in curing bin Cu1, and the resultant enrichment thereof. In these instances, not only will curing bin Cu2 be directly enriched as a fertilizer, but so will curing bin Cu1.

After passing through curing bin Cu1, the gas stream will be recirculated into compost vessel Co. During the recirculation of the gas stream, many biological processes are occurring which consume oxygen. At some point, preferably before the oxygen levels are depleted below 15 percent, and most preferably before the levels drop below 10 percent, additional oxygen should be introduced into the gas stream. While this may be in the form of pure oxygen, thereby minimizing the amount of gas which must also be removed from the system, the handling of pure oxygen in a composting facility is considered to be quite dangerous and adds unnecessary cost to the system. Consequently, air taken from the ambient environment will normally serve as the source for additional oxygen. FIG. 1 illustrates this air inlet at valve 2. However, one or more inlets may be provided throughout the system. For example, introduction of ambient air into the gas stream between compost vessel Co and curing bin Cu2 will serve to lower the temperature and relative humidity of the gas stream, thereby lowering the **load upon the heat exchanger**⁴. Sensors will also most preferably be provided in the system, and at least some of these will most desirably be provided in the gas stream coming from the output of curing bin Cu2. These sensors can monitor the concentration of various contaminants and also the gas flow rate. In the event the gas is vented to ambient, it is possible to monitor and track, continuously if desired, the concentrations of contaminants emitted and also the total mass over a given time interval. These sensors can be used in conjunction with an electronic control system to only release through a particular output device when the contaminants are within a particular range. For example, should the compost within compost vessel Co have an unusually high ammonia emission that overloads the biofiltration function of curing bin Cu2, then valve 1 can be controlled to prevent the release of any gas into the ambient environment, and instead recirculate the entire gas stream. Should this situation not be resolved, and there be a need for additional oxygen, valve 1 can be

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320 controlled to pass the gas stream through biofilter BF prior to release, thereby preventing
321 unwanted emissions into the ambient.

322 Sensors or intermittent testing may also be used to determine one or more of the particular
323 nutrient values of a compost within curing bin Cu2. In one embodiment, the contents of curing
324 bin Cu2 may be maintained therein and exposed to high nitrogen (ammonia or the like) gas
325 streams from compost vessel Co to enrich the compost. At some time, the contents of curing bin
326 Cu2 will reach a nitrogen level high enough to be of significantly more value as a fertilizer than
327 the original compost. When this target value is achieved, the contents of curing bin Cu2 may next
328 be removed and prepared for sale or placement as valuable fertilizer. Similarly, it is conceivable
329 to control the pH of the compost or fertilizer, for example, for the tailoring of compost to a
330 specific or optimum plant growth requirement. In addition, various testing and control is
331 contemplated herein to enable an operator to explicitly extract carbon dioxide, heat or other
332 by-product produced in the process that may be useful. It is noteworthy here that carbon dioxide
333 is also a plant nutrient, and heat can be a valuable resource, particularly in the colder climates⁵.

334 Consequently, the present recirculation system enables the custom production of particular
335 fertilizer or compost blends, and reproducibility within subsequent batches.

336 FIG. 2 illustrates from a top plan view one possible arrangement that is preferred. In this
337 configuration, a plurality of **composting vessels** may be arranged along a row as shown at 1.
338 These bins are connected to a common air conduit which provides both incoming and outgoing
339 flow of the gas stream to each **composting vessel**. When a single **composting vessel** has finished
340 a composting cycle, which in the preferred embodiment may be a fifteen-day cycle, then the
341 **composting vessel** may be disconnected from the common air conduits. The **vessel** may be
342 dumped for remixing, or may alternatively be transported for connection to the initial curing
343 section as a curing bin Cu1. This curing process will typically take approximately thirty days.
344 This curing stage provides only limited energy release and limited moisture production.
345 However, aeration of the curing bin is beneficial, and in most instances, the introduction of
346 additional warmth and moisture prior to passing the gas stream into the **composting vessels** Co is
347 desirable.

348 Once the material within a curing bin Cu1 is adequately cured, the bin may once again be
349 disconnected and transported to the secondary curing location designated by bins Cu2. This
350 secondary curing will typically require an additional approximately 30 days. The secondary
351 curing bins Cu2 serve the additional function of biofiltration, receiving the gases from **compost**
352 **vessels** Co. In the most preferred embodiment illustrated in FIG. 1, the biofiltered output from
353 curing bins Cu2 is recirculated back into curing bins Cu1, and then passed through compost
354 vessels Co. However, in an alternative embodiment, it is contemplated to pass ambient air

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directly into the curing bins Cu1, and exhaust biofiltered air directly to ambient from curing bins Cu2.

The entire composting process will typically require approximately seventy-five days, and will require only minimal user intervention. The containers may be directly transported from one set of interconnection points with the gas stream into another set. Using the air pressure sensors and dampers illustrated, for example in my published international application referenced herein above, the containers will be simply disconnected, moved, and reconnected, with no other actions being required of the operator. Should one of the bins need further treatment such as remixing outlined in the aforementioned international application, the specific procedure will be carried out as outlined in that same international application. Very little additional training is required by the current invention, and the present composting system requires only source materials for operation. No additional biofiltration media is required, thereby eliminating the burden of additional expense associated with typical biofilters or chemical scrubbing equipment and the economic loss of value owing to the loss of nitrogen content.

The economics of the present system is fully appreciated by the recognition that the present inventive system overcomes many of the losses encountered in the prior art. Not only does the compost form the source material for the biofiltration, and thereby simultaneously biofilter and cure, but the biofilter container is now not a separate capital investment. In the prior art systems, a separate dedicated container was required for the biofilter and for the curing bin. In the present preferred embodiment, the curing bin serves the multiple purposes of curing, biofiltration, and fertilizer enrichment, consequently reducing the amount of capital equipment and lowering the operating costs. Likewise, since the entire system operates from a single ventilation loop, it is possible to operate the system from a single blower. No additional blowers are required for either the biofilter or the curing bins. Furthermore, in some severe prior art applications, it was not only necessary to use a biofilter in conjunction with the composting vessel, but also in association with the curing bins. The present invention enables one biofiltration device to serve the needs of both composting vessels and curing bins.

Similarly to the optimization of capital equipment, the flow of energy has been optimized as well in the preferred system. Compost which is ready for curing bin Cu1 will still be slightly exothermic in nature. This energy, which was formerly vented to the atmosphere, will in the present invention be forwarded to the composting vessel Co in the form of preheated air. Similarly, in the prior art the energy released from a typical biofilter is also released directly to ambient, without any effort being made at recovery. In the present preferred recirculating embodiment, this waste energy in the form of a pre-heated gas stream is used as the input into curing bin Cu1. Interestingly, the most preferred operating temperature range for biofiltration is also the correct temperature range for curing in curing bin Cu1. Consequently, previously wasted

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391 heat from biofilters and curing bins is preserved.

392 Where an open loop system is used, or a continuous mixing of fresh air into the system, a bin
393 may also be provided which has a slight negative pressure into which ambient air may be drawn⁶.
394 This may be accomplished through the use of an air permeable membrane or perforate screen,
395 and with the use of a blower system which ensures the slight negative pressure within the bin.
396 Other gas mixing techniques may also be recognized by those skilled in the art.

397 While the foregoing details what is felt to be the preferred embodiment of the invention, no
398 material limitations to the scope of the claimed invention are intended. Further, features and
399 design alternatives that would be obvious to one of ordinary skill in the art in light of the present
400 disclosure are considered to be incorporated herein. The number of possible variants is simply
401 too great to attempt to iterate each herein. The scope of the invention is set forth and particularly
402 described in the claims herein below.⁷

403 * * * * *

1. Line #96, McNelly clearly states: "the invention comprises an array of enclosed containers" and makes no claim or suggestion that his system will work without the compost being contained in vessels or bins. The Crockett invention for capturing the Surplus Microbial Metabolic Heat from compost does not require any form of vessel, bin, or container, and thereby is novel, and a significant improvement because it eliminates the cost of said vessels, containers, and bins.
2. Lines #223-234: **Objectives of the Invention:** There is NO mention of any intent or way to capture the Surplus Microbial Metabolic Heat from the composting mass. The Crockett invention clearly states that the objective of the invention is to capture the Surplus Microbial Metabolic Heat from the composting process
3. While McNelly states that the gas from the vessel will be pasted through a heat exchanger, he makes no suggestion or claim that such heated gas could be captured without the compost being contained in a composting vessel. The Crockett invention states that there is no need for the compost to be in any sort of vessel. The difference in mode of aeration, and the Crockett invention is a significant improvement in that it avoids the cost of the vessels, while also enabling better management of the composting mass, not readily achievable economically when the composting mass is enclosed in such a vessel.
4. Line #308: "Load on the Heat Exchanger" suggests that McNelly's primary intent for the heat exchanger is to cool the processing gas. Beyond that, the McNelly invention

Application #10/708,254, John A. Crockett,

Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

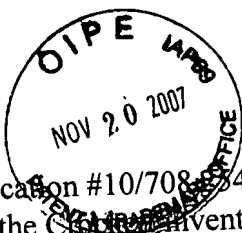
requires and is based on the compost being in enclosed vessels, and McNelly makes no claim of being able to capture the heat from compost that is not enclosed in containers. The Crockett invention states that the process cited in the Crockett invention can effectively capture the Surplus Microbial Metabolic Heat from compost **without** any need for the compost to be any kind of enclosed container, thereby making the Crockett invention a significant improvement over the McNelly invention, avoiding the cost of the vessels.

5. Line # 331-333, While McNelly says his system can capture heat, he makes no claim or description of a way to capture heat without the compost being contained in an enclosed vessel. The most common method of forced aeration is to push the air up through the compost. Without the compost being contained in an enclosed vessel, the heat would immediately mix with ambient air. That off-gas can, and frequently does contain significant foul odors, as well as ammonia, which can burn tender foliage in a greenhouse situation. That is why a heat exchanger is essential. The McNelly invention does not even suggest any way of capturing the heat without the compost being in an enclosed vessel / container.
6. Line #392: **McNelly still refers to the compost being in a BIN** (vessel/container), but he does refer to "ambient air may be drawn" in line #393. In line # 395 he refers to: "a blower system which ensures the slight negative pressure within the bin", and **the Crockett invention does not require any form of bin, vessel or container.**
7. Lines 397-402 are an opened ended 'claim' beyond reason. Everywhere in McNelly's writing he refers to vessels and bins without once suggesting that he can capture heat from compost that is not in any sort of vessel. **The Crockett invention states that the Crockett process can work if the compost is in a "windrow or other shaped pile covering a few square yards, or acres" with no reference what so ever to the compost needing to be in any sort of vessel, container or bin.** Therefore the Crockett invention is a significant improvement over the McNelly invention, and thus patentable.

While there is reference in the literature of people putting pipes through piles of compost, running water through the pipes, those pipes or ducts going through the compost seriously interfere with required frequent turning of the compost. Our research has consistently demonstrated that the compost needs frequent turning to maximize the Surplus Microbial Metabolic Heat. The Crockett process does not require any pipes or ducts to go through the compost, nor does it require that the compost be in any form of vessel, bin or container.

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:



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Why the ~~Current~~ invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

See End Notes on Pages 40 - 41

(1 of 1)

United States Patent

5,587,320

Shindo, et al.

December 24, 1996

Solid organic waste processing apparatus

Abstract

An apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste includes a solid organic matter processing device including a **processing vessel** provided with a crushing unit for receiving and crushing the solid organic waste and a processing unit for agitating and fermenting the crushed waste, a heat exchanger disposed outside the solid organic matter processing device which heat exchanger condenses vapor in a gas supplied from the processing vessel of the solid organic matter processing device to thereby change the vapor to liquid and to discharge the liquid, and gas circulation pipes for providing a gas circulation path through which the inside of the processing vessel of the solid organic matter processing device is operably connected to the heat exchanger and through which a gas in the **processing vessel** of the solid organic matter processing device is supplied into the heat exchanger and almost all of which gas processed in the heat exchanger is returned to the solid organic matter processing device while a portion of the gas processed in the heat exchanger or a portion of the gas supplied from the **processing vessel** of the solid organic matter processing device is discharged to the outside of the apparatus.

Inventors:

Shindo; Yasuhiro (Tochigi-ken, JP), Yamaguti; Usaburo (Tochigi, JP), Ioka; Kazuo (Oyama, JP), Suzuki; Tosio (Tatebayashi, JP), Minagawa; Akihiro (Tochigi-ken, JP), Kitabatake; Syoichi (Tochigi-ken, JP)

Assignee:

Hitachi, Ltd. (Tokyo, JP)

Appl. No.:

08/292,204

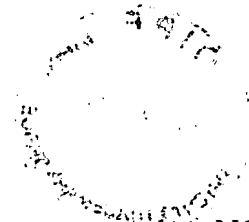
Filed:

August 19, 1994

Foreign Application Priority Data

Application #10/708,254, John A. Crockett,

Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:



Nov 01, 1993 [JP]

5-273395

Current U.S. Class:

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Current International Class:

C05F 17/00 (20060101); C05F 17/02 (20060101); A61L 9/16 (20060101); C12M 003/00 ()

Field of Search:

435/290.1,290.2,290.4

References Cited [Referenced By]

U.S. Patent Documents

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December 1992

Snellink et al.

Foreign Patent Documents

2809344

Sep., 1979

Application #10/708,254, John A. Crockett,
Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

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Application #10/708,254, John A. Crockett,
Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

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Application #10/708,254, John A. Crockett,
Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

Primary Examiner: Redding; David A.

Attorney, Agent or Firm: Antonelli, Terry, Stout & Kraus

Claims

What is claimed is:

1. An **apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste, characterized by comprising:

a solid organic matter **processing device including a processing vessel** provided with a crushing unit for receiving and crushing the solid organic waste and a processing unit for agitating and fermenting the crushed waste;

a heat exchanger disposed outside said solid organic matter processing device which heat exchanger condenses vapor in a gas supplied from the processing vessel of said solid organic matter processing device to thereby change the vapor to liquid and to discharge the liquid; and

gas circulation means for providing a gas circulation path through which the inside of the **processing vessel** of said solid organic matter processing device is operably connected to said heat exchanger and through which a gas in the **processing vessel** of said solid organic matter processing device is supplied into said heat exchanger, almost all of the gas processed in said heat exchanger being returned to said solid organic matter processing device while a portion of the gas processed in said heat exchanger or a portion of the gas supplied from the **processing vessel** of said solid organic matter processing device is discharged to the outside of the apparatus.

2. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, characterized by further including a deodorization processing unit for deodorizing at least a portion of a gas supplied from said **processing vessel** which deodorization processing unit discharges the deodorized gas to the outside and/or deodorizes at least a portion of a gas processed by said heat exchanger and then discharges the deodorized gas to the **outside of the apparatus.**

3. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 2, characterized by further including a liquid purification unit for neutralizing water in said heat exchanger, neutralized water produced in said liquid purification unit being supplied to said deodorization processing unit where the organic matter in the neutralized water is removed while the neutralized water is used to maintain the water in said

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deodorization processing unit to a predetermined level and while excessive water from which the organic matter is removed is discharged.

4. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to any one of claim 1 to claim 3, characterized in that a portion of the gas processed in said heat exchanger is supplied to said crushing unit or to the vicinity of said crushing unit.

5. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1 or claim 2, characterized in that said crushing unit has a charge port for charging the solid organic waste, said processing unit has a heating unit by which said processing unit is kept to a predetermined processing temperature at which the crushed matters to be processed are agitated under the existence of species of aerobic bacteria and sufficiently fermented, said gas circulation means carries out a gas circulation so that a gas containing vapor in said **processing vessel** is supplied from the crushing unit side thereof to said heat exchanger and the gas processed by said heat exchanger is returned to the processing unit of said **processing vessel**, said heat exchanger has an air intake port at the high temperature side thereof for taking air from the outside in an amount corresponding to the air consumed by a fermentation process executed by the aerobic bacteria in said processing unit, said deodorization processing unit has a deodorizing communication pipe branched from a path through which an heat-exchanged gas is returned from the low temperature side of said heat exchanger to said **processing vessel** so that a gas corresponding to an amount of the air taken through said air intake port is deodorized and exhausted to the outside through a deodorizing vessel, and said **processing vessel** further has a storing unit for recovering matters processed by said **processing vessel**.

6. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, characterized in that a drain pipe is disposed to a path for returning the heat-exchanged gas to said **processing vessel** to thereby discharge water produced from the vapor condensed during exchanging of the heat thereof.

7. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1 or claim 2, characterized in that comb-shaped fixed arms are disposed on the bottom of said **processing vessel** in the crushing unit thereof and agitation arms are mounted on a rotary shaft in said crushing unit and said processing unit, respectively and each of said agitation arms located in said crushing unit passes between adjacent ones of said fixed arms in such a manner that it is about to be in contact therewith to thereby crush the solid organic waste.

8. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT
require that the compost be in any form of vessel, container or enclosure of any sort:

the waste according to claim 1 or claim 2, characterized in that a circulation fan is disposed to the path through which a heat-exchanged gas is returned to said **processing vessel** to thereby circulate the gas to said **processing vessel**, and that means for introducing outside air is provided which supplies the same into said heat exchanger.

9. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 6, characterized in that the extreme ends of at least a pair of said adjacent agitation arms are connected by a coupling member, and that said coupling member promotes agitation in said **processing vessel** and prevents the solid organic waste from adhering to said **processing vessel**.

10. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, characterized in that a circumferential angle of each of the agitation arms mounted on a rotary shaft is continuously dislocated circumferentially by a predetermined angle so that the solid organic waste is axially moved toward the direction in which the waste is left from said crushing unit.

11. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, characterized in that said **processing vessel** is subdivided into multi-staged **vessels** disposed vertically with an upper **processing vessel** including a crushing unit having a charge port and with another lower **processing vessel** being provided with a processing unit, and that processed matters sequentially overflow the end plates of said respective **processing vessels**.

12. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, characterized in that intermediate partitions are disposed at least in **the processing units of said processing vessels** to separate the inside of said **processing vessels** to thereby provide a **plurality of vessel portions** having dam effect for the matters to be processed.

13. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, wherein said **processing vessel** has a rotary shaft extending therethrough and said crushing unit has agitation arms formed to a bar-shape.

14. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, wherein said processing unit has a rotary shaft extending therethrough, agitation arms being secured to the rotary shaft and being inclined with respect to said rotary shaft by a predetermined angle and being formed to a bar-shape.

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

273 15. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting
274 the waste according to claim 1, wherein said processing vessel has a rotary shaft extending
275 therethrough and the apparatus further comprises a drive mechanism connected to said rotary shaft
276 to rotate the agitation arms in said processing vessel and said rotary shaft is made to rotate in
277 sequence in a usual direction, to stop and to rotate in a reverse direction for a predetermined
278 period of time, respectively.

279
280 16. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting
281 the waste according to claim 1, characterized in that said processing vessel has an upper
282 box-shaped processing vessel, a lower box-shaped processing vessel disposed in two stages, an
283 air intake pipe for taking air from said upper stage processing vessel, and an air return pipe for
284 returning air to said lower stage processing vessel, both of said pipes being disposed outside of
285 said processing vessels, said heat exchanger being connected to said air intake pipe and said air
286 return pipe, air supply means being provided to supply outside air to said heat exchanger, that said
287 heat exchanger is provided with a vertically disposed tubular inlet pipe connected to said air
288 intake pipe, a vertically disposed tubular outlet pipe connected to said air return pipe, and a
289 plurality of heat exchange pipes connected to said inlet pipe and said outlet pipe and extending
290 substantially in a horizontal direction, that a drain pipe is disposed below said outlet pipe, that
291 said processing vessel has heating means and temperature keeping means so that the inside
292 of said processing vessel is kept to a predetermined temperature at which aerobic bacteria are
293 active, and that said gas circulation means has a circulation fan disposed in the midway of said air
294 return pipe for circulating air in said processing vessel to said heat exchanger.

295
296 17. An apparatus for processing solid organic waste by crushing and/or agitating and fermenting
297 the waste according to claim 11, characterized in that a waste discharge port is disposed in said
298 upper processing vessel, an upper end plate being disposed in said upper processing vessel on the
299 side thereof opposite to said waste charge port so that processed matters overflow said end plate
300 and drop into said lower stage processing vessel, said lower processing vessel being formed
301 shorter than said upper processing vessel while a lower end plate is disposed at one end of said
302 lower processing vessel, a discharging matter storing unit having a length corresponding the
303 difference between said upper stage processing vessel and said lower stage processing vessel
304 being disposed below said upper stage processing vessel so that the processed matters which
305 overflow the lower end plate of said lower stage processing vessel drop into said discharging
306 matter storing unit, a rotary shaft, bearings and drive means for driving said rotary shaft being
307 disposed regarding each of said upper and lower processing vessels arranged in the form of the
308 two stages which rotary shaft is provided with agitation arms, and that fixed arms extending from
309 the bottom of said upper stage vessel are disposed below the waste charge port of said upper stage
310 processing vessel and between a plurality said agitation arms so that charged waste is crushed by
311 said agitation arms and said fixed arms.

Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

- 312 18. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
313 the waste according to claim 11, characterized in that said gas circulation means is disposed in the
314 midway of a path comprising said air intake pipe, said air return pipe and said heat exchanger
315 connected to said air intake pipe and said air return pipe, said gas circulation means being
316 provided with an air intake port for taking outside air, said deodorization processing unit being
317 provided with a deodorizing communication pipe connected to said air return pipe located
318 between said circulation fan and said **processing vessel**, an air exhaust pipe for exhausting a
319 deodorized gas, a **deodorizing vessel in which active sludge is sealed, for blowing air supplied**
320 **from said deodorizing communication pipe into the active sludge and a pump so that air**
321 **from the active sludge is exhausted into the atmosphere through said a blow pipe air**
322 **exhaust pipe.**
323
- 324 19. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
325 the waste according to claim 11, characterized in that wherein an air intake pipe and an air return
326 pipe are detachably connected to said **processing vessel** by connecting means; an auxiliary frame
327 for supporting said **processing vessel** being formed separately from a main frame for supporting
328 said heat exchanger, air supply means and deodorizing means to which auxiliary frame are
329 connected all of rotary shafts of said upper stage and lower stage, bearings, a sprocket and a chain
330 for connecting said upper rotary shaft to said lower rotary shaft, an insulation member, and a
331 portion of an outside box so that said auxiliary frame and components connected thereto can be
332 easily removed from said main frame when maintenance and service are carried out.
333
- 334 20. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
335 the waste according to claim 11, characterized in that the agitation arms mounted on said rotary
336 shaft are axially inclined in the range of 3.degree.-45.degree..
337
- 338 21. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
339 the waste according to claim 11, characterized in that an intermediate partition is disposed to at
340 least one of the fermenting unit of said upper stage **processing vessel** and said lower **processing**
341 **vessel** so that processed matters in said **processing vessel** overflow said intermediate partition and
342 sequentially move to an adjacent region.
343
- 344 22. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
345 the waste according to claim 1, further including a liquid purification unit for removing an organic
346 matter from liquid condensed by said heat exchanger which unit neutralizes the liquid, a
347 **processing vessel** of a liquid organic matter processing device being made to include aerobic
348 bacteria filled therein and a heating means disposed on the outside wall surface of said **vessel**, and
349 that each of said solid organic matter processing device, said heat exchanger and said
350 deodorization processing unit is detachably arranged through a frame.

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

351 23. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
352 the waste according to claim 1, characterized in that said solid organic matter processing **device**
353 **comprises rectangular box-shaped processing vessels** each having a bottom portion connected
354 in parallel at two curved bottom surfaces each having arc-shaped cross section, two rotary shafts
355 disposed in the longitudinal direction of said **processing vessels** each of which shaft has a
356 plurality of agitation arms fixed thereto, fixed arms planted on the wall surface of said **processing**
357 **vessel** and not interfering with said agitation arms, and a partition plate for separating a crushing
358 unit from a processing unit, each of the rotary shafts in said **processing vessels** being disposed at
359 the center of the arc of the curved bottom surface, and that the position where said two curved
360 bottom surfaces are connected is located below said rotary shafts while the partition plate forms a
361 gap between it and the inside wall **of said processing vessel**.
362

363 24. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
364 the waste according to claim 3, characterized in that a liquid purification unit of a gas and liquid
365 processing unit includes an adjustment tank filled with a weak alkaline material and a processing
366 tank connected to said adjustment tank which processing tank is filled with a carrier to which
367 microorganisms are fixed so that liquid passing through said adjustment tank is neutralized
368 thereby while the organic material of the liquid passing through said adjustment tank is removed
369 thereby.
370

371 25. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
372 the waste according to claim 3, wherein a deodorization processing unit of a gas and liquid
373 processing unit has microorganisms for decomposing an odor and for deodorizing a gas by
374 causing the gas to come into contact with the microorganisms.
375

376 26. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
377 the waste according to claim 3, characterized in that a liquid purification unit comprises an
378 adjustment tank filled with a weak alkaline material, a deodorizing tank filled with a liquid mixed
379 with a carrier to which microorganisms are fixed and a water level tank having a discharge pipe
380 disposed at the same position as the liquid surface of said deodorizing tank, said adjustment tank
381 being connected to said deodorizing tank, said water level tank being connected to said
382 deodorizing tank through a pipe at the lower portions thereof, and that the microorganisms fixed
383 to the carrier in said deodorizing tank decompose both the odor of a gas introduced from said
384 processing unit and the organic matter of liquid passing through said adjustment tank.
385

386 27. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting
387 the waste according to claim 1, characterized by further comprising a storage tank connected to
388 the downstream side of said solid organic matter processing device through a connection pipe
389 including a blower for storing processed and discharged matters, a water storage tank connected to

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a liquid purification unit through a connection pipe, and sprinkling means connected to said water storage tank through a water discharge pipe having a pump to thereby supply the processed and discharged matters and water to the surroundings of the location where said apparatus is installed.

28. **An apparatus** for processing solid organic waste by crushing and/or agitating and fermenting the waste according to claim 1, including a control unit for stopping the operation of said processing unit after a lapse of a predetermined period of time but continuously operating only said gas circulation means.

29. Apparatus for composting solid organic waste with supplying composting air, **comprising:**

a processing vessel having a top charging opening for the waste material which charging opening is provided at one end of the **vessel**, and crushing means for crushing, agitating and composting the waste material which crushing means is arranged beneath the charging opening;

a heat exchanger disposed outside of the vessel for condensing the water vapor contained in the composting air;

an air-circulation means for providing an air circulation path from the **vessel** to the heat exchanger and from the latter one back to the **vessel**;

a fresh-air inlet **into the apparatus** and an used air-outlet **from the apparatus**;

a **storing unit for the compost** which storing unit is arranged at the other end of the **vessel**; and

conveyor means for moving the waste from the crushing unit through the vessel to the storing unit.

30. Apparatus for composting solid organic waste with supplying composting air, **comprising:**

a processing vessel having a top charging opening for the waste material which charging opening is provided at one end of the **vessel**, and crushing means for crushing, agitating and composting the waste material which crushing means is arranged beneath the charging opening;

a heat exchanger disposed outside of the **vessel** for condensing the water vapor contained in the composting air; ¹

an air-circulation means for providing an air circulation path from the vessel to the heat exchanger and from the latter one **back to the vessel**;

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

~~a fresh-air inlet into the apparatus~~ and an used air-outlet from the apparatus;

a storing unit for the compost which storing unit is arranged at the other end of the **vessel**;

conveyor means for moving the waste from the crushing unit through the **vessel** to the storing unit; and

a control unit for stopping the operation of said processing unit after a lapse of a predetermined period of time but continuously operating only said air-circulation means.

Description

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a solid organic waste **processing apparatus**, and more specifically, to a solid organic waste processing apparatus for processing solid organic waste as a whole such as kitchen waste (kitchen garbage), waste dumped in towns, waste generated in a food manufacturing process, biomass and the like by aerobic fermentation, and this apparatus can be widely applied to a home use, business use and public use and further used in an industrial scale.

2. Description of the Related Art

Recently, a technology for processing solid organic waste by aerobic fermentation or a technology for making waste to compost is evaluated again because it is not only a processing method by which no pollution is caused but also a technology for reusing waste and returning waste to nature.

In particular, as a stock breeding industry which has consumed a large amount leftover rice is declined, the development of a processing apparatus is desired which is capable of processing kitchen waste or so-called kitchen garbage, while solving odor pollution, at a high speed and a high decomposition ratio is desired.

Conventionally, most of solid waste such as waste generated from agriculture, sludge generated from a sewer system, and the like is made to compost by causing it to naturally ferment in such a manner that it is left on a field for a long time without positively managing it.

On the other hand, examples of development by which fermentation is accelerated by agitating

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

waste by the use of a fermentation apparatus or partially managing the supply of oxygen are increased. For example, Japanese Patent Unexamined Publication No. 1-145388 and the like are known as the examples.

Nevertheless, in the conventionally developed processing apparatuses, when waste containing a large amount of water such kitchen waste and the like is processed at a high speed by fermentation carried out at a high temperature, an assistant raw material such as sawdust, rice hulls and the like serving as a water content adjustment material must be added in addition to a raw material. If the raw material is processed as it is, since it has an average water content of 80%, water exists excessively in the process in which the material is processed, and thus the raw material cannot be fermented. When the assistant raw material is to be added, a problem arises in that not only it must be stably obtained but also a processing efficiency of the raw material is lowered by an amount of the added assistant raw material and a volume of resulting compost is increased².

Further, since the conventional processing apparatuses employ a so-called batch system, when waste is charged once, next waste cannot be charged until a predetermined processing time has elapsed. Thus, these apparatuses are very inconvenient as a waste processing apparatus for processing continuously generated waste.

Further, since the conventional apparatus pay no attention to a problem of environmental pollution, they scatter a bad odor and a lot of vapor to surroundings.

SUMMARY OF THE INVENTION

A solid organic waste processing apparatus for processing solid organic waste by crushing and/or agitating and fermenting the waste of the present invention has a solid organic matter processing device including a processing vessel provided with a crushing unit for receiving and crushing the solid organic waste and a processing unit for agitating and fermenting the crushed waste, a heat exchanger disposed outside the solid organic matter processing device for condensing vapor in a gas supplied from the processing vessel of the solid organic matter processing device³, changing the vapor to liquid and discharging the liquid, and a gas circulation means for forming a gas circulation path by which the inside of the processing vessel of the solid organic matter processing device is operably connected to the heat exchanger and through which a gas in the processing vessel of the solid organic matter processing device is supplied into the heat exchanger and almost all of the gas processed in the heat exchanger is returned to the solid organic matter processing device and further discharging a portion of the gas processed in the heat exchanger to the outside of the apparatus or a portion of the gas supplied from the processing vessel of the solid organic matter processing device to the outside thereof.

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It is preferable that the processing apparatus of the present invention further includes a deodorization processing unit for deodorizing at least a portion of a gas supplied from the processing vessel and discharging a deodorized gas to the outside air and/or deodorizing at least a portion of a gas processed by the heat exchanger and discharging a deodorized gas to the outside air.

The processing apparatus of the present invention may further include a liquid purification unit for neutralizing water produced in a process carried out by the heat exchanger, neutralized water produced by the liquid purification unit is supplied to the deodorization processing unit and the organic matter contained in the neutralized water is removed by the deodorization processing unit as well as the neutralized water is used to keep the water in the deodorization processing unit to a predetermined level.

It is preferable that the processing apparatus of the present invention supplies a portion of the gas processed by the heat exchanger to the crushing unit or the vicinity of the crushing unit and promotes the dehydration of crushed solid organic waste.

The processing apparatus of the present invention can connect the extreme ends of a plurality of the agitation arms by a connecting member so that the connecting member promotes an agitating operation carried out in the processing vessel and prevents solid organic waste from adhering to the processing vessel.

The processing apparatus of the present invention includes a control unit for stopping the operation thereof after a predetermined period of time and continuously operating only the gas circulation means so that the apparatus is adapted to an unused state for a long period.

Condensed liquid may be discharged through a drain pipe disposed to a path for returning the heat-exchanged gas to the processing vessel, comb-shaped fixed arms are disposed on the sides or bottom of the processing vessel in the crushing unit, agitation arms are mounted on a rotary shaft in the crushing unit and processing unit, respectively, the rotary shaft passing through the processing unit from the crushing unit, and each of the agitation arms located in the crushing unit passes between adjacent ones of the fixed arms in such a manner that it is about to be in contact with the fixed arms when rotated to have a function for crushing solid organic waste.

Further, the gas circulation means includes a path for returning the heat-exchanged gas to the processing vessel, a circulation fan disposed in the path for circulating the gas to the processing vessel and a path for supplying the gas in the processing vessel to the heat exchanger, and a means for taking outside air into the heat exchanger may be provided, when necessary.

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Although the above **processing vessel** may be composed of a single vessel, it is preferable that the vessel is subdivided into a plurality of multi-staged vessels to reduce the size of the apparatus as a whole. When the **vessel** is subdivided into the **plurality of vessels**, it is preferable that the uppermost **vessel** is composed of a **processing vessel** having a crushing unit provided with a charge port of solid organic waste and a processing unit and a lower **vessel** is composed of a **processing vessel** mainly composed of a processing unit, and moreover matters to be processed overflow the end plates of the respective **processing vessels**. Then, a storing unit is disposed in the vicinity of the end plate of the final stage **vessel** so that processed matters (made of dry powder) overflowing the end plate is recovered to the storing unit. When a predetermined amount of the processed matters is recovered, the storing unit can be taken out to the outside by opening a discharge gate.

Further, an intermediate partition(s) may be disposed at least in the processing unit(s) of the **processing vessel(s)** to separate the inside of the **processing vessel(s)** to substantially a plurality of **vessels** to provide a dam effect to the matters to be processed.

Further, to describe the configurational arrangement of the agitation arms to be mounted on the rotary shaft, the agitation arms in the crushing unit are formed to a polygonal bar shape (including circular shape and ellipse shape) and are preferably disposed very near to comb-shaped fixed arms disposed on the bottom of the processing vessel so that the agitation arms are about to be in contact with the fixed arms in order to increase a crushing effect.

The agitation arms in the processing unit may be mounted on the rotary arm vertically with respect to the rotation axis thereof but they may be inclined by a predetermined angle so that matters to be processed do not stay on the bottom of the processing unit but are swung. When the agitation arms are mounted vertically with respect to the rotary arm, they are generally formed to a bar shape, strip shape, or bar shape or strip shape each having a different width at the upper and lower ends thereof and these agitation arms are radially disposed around the rotary shaft. Further, when the agitation arms are inclined with respect to the rotary arm, they may be further formed to a disk shape. As shown in FIG. 16, a plurality of the agitation arms are preferably mounted on the rotary arm by being continuously dislocated with respect to an circumferential direction by a predetermined angle (preferably in the range of 30.degree.-90.degree.). With this arrangement, when the agitation arms are rotated, solid organic waste is moved from the crushing unit.

A heating means is disposed on the outside wall of the **processing vessel**, for example, on the bottom of the vessel and since the processing vessel is usually heated to 50.degree.-80.degree. C., when matters to be processed stay on the bottom of the **vessel**, they are baked and adhered to the bottom of the **vessel** in a paste state and lower thermal transmission. Therefore it is effective to swing the matters to be processed by the agitation arms.

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The heating mean disposed on the **processing vessel** has a U-shaped sheath heater or a plate-shaped heater. The plate-shaped heater is preferable because it can uniformly heat a **vessel wall**. In any way, it is important that heat is applied and maintained so that fermentation is sufficiently carried out in the processing unit and a temperature is preferably controlled by a thermostat for the adjustment of temperature.

To describe the direction in which the agitation arms are rotated in the processing vessel and a rotation schedule, although they may be rotated in a predetermined direction continuously or intermittently, it is more effective that they are driven in the three sequences of forward rotation, stop and backward rotation for a predetermined period of time, respectively. Further, the **processing vessel is formed to a rectangular box-shape** having a bottom portion obtained by connecting in parallel two curved bottom surfaces each having arc-shaped cross section and includes two rotary shafts each disposed in the longitudinal direction of the **processing vessel** at the center of the arc of each of the curved bottom surfaces, fixed arms planted on the wall surface of the **processing vessel** so as not to interfere with the agitation arms, and a partition for separating a crushing unit from a processing unit, and the position where the two curved bottom surfaces are connected is located lower than the rotary shafts.

Further, there may be provided a condensed liquid purification unit including an adjustment tank and a processing tank. The adjustment tank is filled with a weak alkaline material (for example, limestone etc.) for neutralizing liquid passing therethrough and the processing tank is filled with a carrier to which microorganisms for removing an organic matter in the liquid are fixed.

The deodorization processing unit may include a deodorizing tank which is filled with liquid (for example, water) with which mixed is a carrier having microorganisms fixed thereto and disposed downward of an adjustment tank and a water level tank (870) having a discharge pipe (880) positioned at the same location as the liquid level of the deodorizing tank (840) and disposed downward of the deodorizing tank (840), the above microorganisms being similar to those used in the condensed liquid purification unit.

The processing apparatus of the present invention may include a storage tank (250) for storing processed discharging matters which is connected to the downstream side of a solid organic matter processing device (A) through a connection pipe (240) having a blower (245), a water storage tank (270) connected to a liquid purification unit through a connection pipe and a sprinkling means (275, 280, 290).

A feature of the present invention is to effectively remove water which is contained in kitchen garbage in an average amount of about 80%; to effectively crush matters to be processed which are contained in the **fermentation vessel (processing vessel)** through the crushing unit, mixing

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these matters with species of bacteria so that they are sufficiently fermented by species of aerobic bacteria in the processing unit and dried.

The inside of the **processing vessel** is arranged to be kept to a temperature of, for example, 50.degree.-80.degree. C. at which fermentation can be sufficiently carried out by species of aerobic bacteria, and specifically there are provided an air taking out pipe for taking out air from the **processing vessel**, an air return pipe for returning air to the **processing vessel** and a heat exchanger connected to the air taking out pipe and air return pipe. If desired, an air supply means may be provided to take in outside air and supplying the same to the heat exchanger.

By adopting the constitution, steam generated in the **processing vessel** by the heating therein passes the air-taking-out pipe and enters a plurality of cooling tubes which the heat exchanger comprises. In the heat exchanger there are used the cooling tubes each having a large diameter such as, for example, 18 mm in the example of the present invention so that the cooling tubes may not be clogged by the fine particles of the processed matters. Thus, regarding the steam flowing therethrough, a part of the steam flowing along and in the vicinity of the inner diameter surface of each of the cooling tubes is cooled to be condensed to water, and another part of the steam flowing along the center portion of each of the cooling tubes returns into the **processing vessel** through the air return pipe without being condensed. The condensed water become liquid droplets and is discharged outward of the apparatus through a drain pipe.

The steam returned into the **processing vessel** through the air return pipe acts to keep such a necessary level of moisture that sufficient fermentation occurs by species of aerobic bacteria. The steam is circulated between the **processing vessel** and the heat exchanger, and a state of high moisture is maintained until water is substantially completely removed.

Thus, in comparing the apparatus of the present invention with prior art apparatus in which there is no circulation system between a heat exchanger and a processing vessel, although in the prior art apparatus the water in the processing vessel is quickly removed outwardly and becomes substantially zero or is in a very low level, in the apparatus of the present invention the steam and a high level of moisture are maintained in the processing apparatus for a long period of time, which steam and high level of moisture can bring about a very favorable condition for the fermentation generated by the aerobic bacteria. Namely, both of the heat exchanger and the circulation constitution comprising the air-taking-out pipe and the air-return pipe in the present invention act to realize at the same time both respects, which apparently contradict each other, that the water is removed for reducing the weight of matter to be processed and that the moisture in the processing vessel is maintained in such a necessary level as the sufficient fermentation can occur by the action of the aerobic bacteria.

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Further, in the apparatus of the present invention there are provided a deodorizing communication pipe in a part of the air-return pipe, a deodorizing device communicated with the deodorizing communication pipe, and an air-discharging pipe communicated with the deodorizing device, so that molecules of a sickly odor are decomposed by bacteria received in the deodorizing device and gas substantially having no odor is discharged. Otherwise, a portion of the air from which water is removed may be directly exhausted. Since the pressure in the processing vessel is lowered in proportion to an amount of the exhausted air, fresh air flows thereinto from a separately provided air intake port. Note, an amount of taken air corresponds to air required (consumed) when matters to be processed are fermented in the processing unit.

When this process is cyclicly repeated, water is effectively and continuously removed from the air in the processing vessel and odor is removed from exhausting air as well as fresh air flows into the processing vessel so that aerobic fermentation can be continuously carried out.

Regarding the adjustment of water contained in the waste received in the processing vessel, an intermediate partition plate disposed in the processing vessel acts in a manner explained below. That is, when the waste in the processing vessel becomes light in weight by the reduction of the water, the waste moves beyond the partition plate to thereby falls into an adjacent vessel. Thus, by setting the intermediate partition plate to have a proper level of height, the waste is maintained in the processing vessel while the waste has a minimum water level necessary for the waste to be fermented, and the waste is moved into the adjacent vessel when the water contained in the waste is reduced to be less than the minimum water level, that is, the intermediate partition plate has a function for automatically adjusting water.

Another feature of the present invention is to use the processing vessel for a plurality of objects and maximize the space factor of the apparatus by taking the disposition of components into consideration so that the apparatus is made compact with excellent cost performance.

More specifically, the processing vessel executes the four functions in total of (1) crushing kitchen garbage, (2) mixing charged kitchen garbage with fermentation bacteria, (3) supplying air to the fermentation bacteria, and transferring matters to be processed from an upstream side to a downstream side.

More specifically, when kitchen garbage is charged in to the processing vessel from a waste charge port in the state that fermentation bacteria (species of aerobic bacteria) is previously prepared at the lower portion of the processing vessel, first, the charge garbage is held between the agitation arms and the fixed arms extending from the bottom of the vessel and crushed by them in the crushing unit located below the waste charge port as the agitation arms rotate, then the garbage is mixed with the fermentation bacteria as the agitation arms rotate. At the same time, air is

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702 supplied to the fermentation bacteria by agitation.

703
704 When the kitchen garbage is charged from the waste charge port, the garbage overflows, and when
705 a partition is provided, overflowed garbage flows into the next region from the upper portion of the
706 partition and further overflows an end plate and drops and flows into a discharging matter storing
707 unit and transferred. When the apparatus has tow-staged processing vessels and no partition is
708 provided, matters to be processed overflow the end plate of the upper stage processing vessel and
709 drops into the lower stage processing vessel.

710
711 This disposition is very rational and has an excellent space factor and thus the apparatus can be
712 made compact with an excellent cost performance.

713
714 In a case where the apparatus has the two rotary shafts and the connecting portion where the two
715 curved bottom surfaces are connected each other is located below the rotary shafts, the processing
716 capacity of the processing vessel can be increased, matters to be processed being frequently
717 transferred in the vessel and an area where fermentation bacteria are mixed and to which air is
718 supplied is increased.

719
720 When the solid organic matter processing device is assembled separately from a gas and liquid
721 processing device and they are assembled in a final process or at a site where the apparatus is
722 installed, the assembly and transportation of the apparatus can be rationalized.

723 724 BRIEF DESCRIPTION OF THE DRAWINGS

725
726 FIG. 1 is a schematic diagram partially in cross section of an embodiment of a solid organic waste
727 processing apparatus of the present invention;

728
729 FIG. 2 is a side view of another embodiment of the solid organic waste processing apparatus of
730 the present invention in the state that an outside box is removed;

731
732 FIG. 3 is a backside view of the solid organic waste processing apparatus when viewed from a P
733 direction of FIG. 2;

734
735 FIG. 4 is a front longitudinal cross sectional view of the main part of the solid organic waste
736 processing vessel;

737
738 FIG. 5 is a backside view of the solid organic waste processing apparatus when viewed from the P
739 direction of FIG. 2 in the state that an outside box and an air supply means are removed;

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FIG. 6 is a side view of a still another embodiment of the solid organic waste processing apparatus of the present invention in the state that an outside box is removed;

FIG. 7 is a front longitudinal cross sectional view of a processing vessel of a further embodiment of the solid organic waste processing apparatus of the present invention;

FIG. 8 is a front longitudinal cross sectional view of a further embodiment of the solid organic waste processing apparatus of the present invention;

FIG. 9 is a side cross sectional view of the processing apparatus;

FIG. 10 is a diagram explaining a processing vessel used in FIG. 9;

FIG. 11 is a front longitudinal cross sectional view of a gas and liquid processing unit used in the solid organic waste processing apparatus of the present invention;

FIG. 12 is a side view of the main part showing the arrangement of a processing unit of the solid organic waste processing apparatus of the present invention;

FIG. 13 is a schematic diagram showing a further embodiment of the solid organic waste processing apparatus of the present invention;

FIG. 14 is a front schematic view showing a further embodiment of the solid organic waste processing apparatus of the present invention;

FIG. 15 is a schematic view showing a further embodiment of the solid organic waste processing apparatus of the present invention; and

FIG. 16 is a perspective view showing the state that the positions where agitation arms are mounted on a rotary shaft are continuously dislocated circumferentially by a predetermined angle.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Embodiment 1

FIG. 1 is a schematic diagram showing an example of a processing apparatus of the present invention having a processing vessel arranged as a box-shaped single vessel, wherein the processing vessel 1 has a crushing unit 1a and a processing unit 1b. The crushing unit 1a has a comb-shaped fixed arm 24 fixed to the bottom of the vessel and the processing unit 1b has an end

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780 plate 16 disposed at the terminal end thereof. A waste charge port 15 is disposed on the crushing
781 unit 1a of the **processing vessel 1** in such a manner that it can be opened and closed when
782 necessary. A discharging matter storing unit 18 is disposed adjacent to the end plate 16 of the
783 processing unit 1b and further a discharge gate 26 for taking out the storing unit 18 constitutes a
784 portion of the outside wall provided with the wall surface of the **processing vessel 1**.

785
786 Further, a rotary shaft 20, which extends through the crushing unit 1a and processing unit 1b and
787 has an end connected to a drive means 22, is disposed at the center of the **processing vessel** and a
788 plurality of agitation arms 23 are fixed radially to the rotary arm 20 at predetermined intervals. A
789 heater 13 as a heating means is disposed on the outside wall of the bottom of the **processing**
790 **vessel** so that the **processing vessel** is kept to a temperature at which waste can be effectively and
791 sufficiently fermented.

792
793 A heat exchanger 6 is connected to the crushing unit 1a and processing unit 1b of the **processing**
794 **vessel 1** through an air intake pipe 4 and an air return pipe. The heat exchanger 6 comprises a
795 plurality of cooling tubes, at a high temperature side of which heat exchanger 6 an air intake port
796 27 is opened to the surrounding atmosphere. On the other hand, a drain pipe 11 is disposed on the
797 low temperature side of the heat exchanger 6 to discharge water produced from vapor condensed
798 by exchanging the heat thereof, a circulation fan 14 being disposed in the midway of the air return
799 pipe 5 to forcibly return air to the processing unit 1b. Therefore, a gas in the **processing vessel** is
800 circulated through the air intake pipe 4, heat exchanger 6 and air return pipe 5 which serve as a
801 circulation system, and a suitable amount of fresh air is taken into the circulation system through
802 the air intake port 27 in the midway of the circulation system to effectively promote fermentation
803 in the processing unit 1b. The heat exchanger 6 is cooled by air supplied from a blower⁴ 7.

804
805 A deodorizing communication pipe 28 is branched from the air return pipe 5 between the
806 circulation fan 14 and the processing unit 1b, and a pump 33 is disposed in the midway of the
807 deodorizing communication pipe 28. The pump 33 supplies a gas to a deodorization processing
808 unit 29 under a predetermined pressure and causes the gas to be blown into a deodorizing vessel
809 31 filled with active sludge so that the deodorization processing unit 29 carries out a deodorizing
810 process and exhausts a deodorized air to the outside. An amount of air exhausted to the outside
811 substantially corresponds to air taken in through the air intake port 27, that is, to air consumed by
812 the fermentation in the **processing vessel 1**.

813
814 A charge gate 25 is disposed on the waste charge port 15 of the **processing vessel 1** and the
815 discharge gate 26 is provided with the discharging matter storing unit 18, respectively to separate
816 the inside of the **vessel** from the outside air to prevent the dispersion of heat and odor.

817
818 An operation mechanism of this apparatus will be described. First, kitchen garbage is charged

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819 from the waste charge port 15 of the **processing vessel** 1, solid matters are finely crushed by the
820 crushing unit 1a and sequentially transferred to the processing unit 1b. The processing unit 1b is
821 filled with a predetermined amount of species of aerobic bacteria collected from compost, only
822 when the apparatus is operated for the first time. Crushed organic matters to be processed are
823 fermented in the processing unit 1b by the aerobic species and decomposed. To promote
824 fermentation and decomposition, the processing vessel is kept at a suitable temperature of
825 50.degree.-80.degree. C. at all times by the thermostat (not shown) of the heating means 13. When
826 a predetermined amount of the processed matters (compost) are accumulated in the **vessel**, they
827 overflow the end plate 16 and drop into the storing unit 18 to be recovered therein, and then taken
828 out to the outside by opening the discharge gate 26.

829
830 A gas circulation system for connecting the inside of the **processing vessel** 1 with the heat
831 exchanger 6 will be described below. A gas of high temperature and high humidity (mainly
832 composed of air with an odor) is taken into the high temperature side of the heat exchanger 6 from
833 the crushing unit 1a through the air intake pipe 4. At this time, a predetermined amount of fresh
834 air is taken from the air intake port 27 into the circulation system. In the heat exchanger 6 there
835 are used cooling tubes each of which has a considerably large inner diameter such as, for example,
836 18 mm in the example so that the tubes is prevented from being clogged by fine particles of the
837 waste, with the results that a part of the steam flowing along and in the vicinity of the inner
838 diameter surface of each of the cooling tubes is cooled to be condensed to water, and that another
839 part of the steam flowing along the center portion of each of the cooling tubes returns into the
840 processing vessel 1 through the air return pipe 5 without being condensed. The condensed water
841 becomes liquid droplets and is discharged outward of the apparatus from the low temperature side
842 of the heat-exchanger 6 through a water discharge pipe 11. Further, an amount of air
843 corresponding to air taken into the circulation system from the air intake port 27 is exhausted with
844 the odor thereof removed by the deodorization processing unit 29. Thus, the inside of the
845 circulating system is kept to a state substantially near to the atmospheric pressure at all time.

846
847 Since this apparatus is arranged to have a relatively small size and since waste can be
848 continuously charged into the apparatus, the apparatus can be easily operated and maintained,
849 when it is applied to the industrial fields such as a food processing industry, food service industry
850 and the like where kitchen garbage is generated at all times. The apparatus is advantageous in that
851 it can process waste without depending upon waste collectors and be installed near to the location
852 where waste is generated because surroundings are not adversely affected by the apparatus.
853 Further, since compost is almost odorless dry powder with a very high added value and can be
854 recovered as manure for raising farm products, garden plants, other general plants, this apparatus
855 is preferable from the view point of the reuse of waste.

856
857 Embodiment 2

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858 This embodiment shows another apparatus of the present invention having two-staged **processing**
859 **vessels**. The embodiment will be described below with reference to FIG. 2 and FIG. 3. FIG. 3 is a
860 side view of the apparatus in the state that an outside box is removed and FIG. 3 is a backside
861 view of the apparatus when viewed from a P direction of FIG. 2. The arrangement of the
862 apparatus will be described with reference to the figures. Numeral 1 denotes a **processing vessel**
863 which is formed to a horizontally long box shape and has an upper state **processing vessel** 2 and a
864 lower stage **processing vessel** 3.
865
866 Numeral 4 denotes an air intake pipe for **taking air from the upper state processing vessel** 2,
867 and numeral 5 denotes an air return pipe for returning air to the lower state **processing vessel** 3.
868 The air intake pipe 4 and air return pipe 5 are disposed outside the **processing vessel** 1 and
869 connected to a heat exchanger 6 disposed outside the **processing vessel** 1 in the same way.
870
871 Numeral 7 denotes an air supply means for taking outside air into the heat exchanger 6 and
872 supplying the same. The heat exchanger 6 has a vertical and cylindrical inlet pipe 8 to be
873 connected to the air intake pipe 4, a vertical and cylindrical outlet pipe 9 to be connected to the air
874 return pipe 5 and a plurality of cooling tubes 10 extending in a substantially horizontal direction
875 and connected to the inlet pipe 8 and outlet pipe 9.
876
877 A drain pipe 11 is disposed below the outlet pipe 9 and has a water discharge hole 12 opened to
878 the outside at a lower portion of the apparatus.
879
880 The **processing vessel 1 has a heating means** 13 and a temperature keeping means (not shown)
881 and a temperature is controlled by a thermostat so that the inside of the processing vessel 1 is kept
882 at 50.degree. C.-60.degree. C. at all times.
883
884 A circulation fan 14 is disposed in the midway of the air return pipe 5 to circulate air in the
885 **processing vessel** 1 to the heat exchanger 6.
886
887 FIG. 4 shows a front vertical cross sectional view of the main part of the **processing vessel** 1, in
888 which a right and left side are reversed to those shown in FIG. 3 (backside view). The
889 arrangement of the **processing vessel** 1 will be described with reference to FIG. 4 in more detail.
890
891 The function of the upper stage processing vessel 2 can be divided to a crushing unit 2a and a
892 processing unit 2b adjacent to it from the function thereof. A waste charge port 15 is disposed on
893 the crushing unit 2a and an upper end plate 16 is disposed to the end of the processing unit 2b on
894 the opposite side of the waste charge port 15. This upper end plate 16 has a function as a dam for
895 storing a predetermined amount of matters to be processed in the **processing unit** 2b and a level
896 at which the matters to be processed are overflowed to the lower stage **processing vessel** 3 can be

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adjusted by suitably selecting the height of the upper end plate 16.

Species of bacteria 17 for fermentation are prepared on the bottoms of the upper stage processing vessel 2 and lower stage processing vessel 3, respectively. Note, the preparation of the species of bacteria 17 is needed only when the apparatus is operated for the first time, and when the apparatus is operated steady, there are always exist an sufficient amount of aerobic bacteria which proliferate by themselves. Thus, the species of bacteria 17 need not be newly prepared.

A discharging matter storing unit 18 having a length corresponding to the difference between the upper stage **processing vessel** and the lower stage **processing vessel** is disposed under the upper stage **processing vessel** 2 (more specifically, under the crushing unit 1a) and a lower end plate 19 is disposed on the discharged matter storing unit 18 side of the lower stage **processing vessel** 3.

The upper stage **processing vessel** 2 is provided with a rotary shaft 20 and bearings 21 and the lower stage **processing vessel** 3 is provided with a rotary shaft 20' and bearings 21 and further a driving means 22 is provided to drive the rotary shaft 20, 20'. Each of the rotary shafts 20, 20' is provided with a plurality of agitation arms 23. Further, fixed arms 24 extending from the bottom of the **vessel** are disposed in the crushing unit 2a located below the waste charge port 15 of the upper stage processing vessel 2 and each fixed arm 24 is located between each pair of the plurality of agitation arms 23.

Charged wastes are held between the agitation arms 23a in the crushing unit 2a and the fixed arms 24 and crushed therebetween and further gradually pushed and flown into the processing unit 2b and mixed with the species of bacteria 17 prepared on the bottom of the vessel by the rotation of the agitation arms 23b.

The matters to be processed which have been gradually pushed and flown by charged waste overflow the upper end plate 16 of the upper stage **processing vessel** 2 and drop into the lower stage **processing vessel** 3. The portion of the matters which have not been sufficiently fermented is perfectly fermented in the lower stage **processing vessel** 3. The matters to be processed caused to flow through the **processing vessel** 3 overflow the lower end plate 19 of the **processing vessel** 3 and drop into the discharging matter storing unit 18 and recovered as useful powder compost.

A charge gate 25 is disposed on the waste charge port 15 of the **processing vessel** 2 and a discharge gate 26 is disposed to the discharging matter storing unit 18 of the lower **processing vessel** 3 to separate the inside of the vessels from the outside air to prevent the dispersion of heat and odor.

FIG. 5 shows a backside view of the **processing apparatus** viewed from the direction P of FIG. 2

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936 in the same way as FIG. 3 in which an outside box and air supplying means are removed. This
937 figure mainly explains the relationship of piping for connecting the heat exchanger 6 to the
938 **processing vessel 1** and an example of arrangement of a deodorization processing unit 29 in
939 detail.

940
941 An air intake port 27 for taking fresh air is disposed in the midway of a path interconnecting the
942 air intake pipe 4 and air return pipe 5 and heat exchanger 6 connected to them.

943
944 A deodorizing communication pipe 28 is disposed to a part of the air return pipe 5 (connected to
945 the low temperature side of the heat exchanger 6) between the **processing vessel 1** and the
946 circulation fan 14 (refer to FIG. 2) and the deodorization processing unit 29 is connected to the
947 deodorizing communication pipe 28. An air exhaust pipe 30 is connected to the deodorization
948 processing unit 29.

949
950 The deodorization processing unit 29 includes a deodorizing vessel 31 in which active sludge is
951 contained, an air blowing pipe 32 for blowing air from the deodorizing communication pipe 28
952 into the active sludge and a pump 33. The air supplied onto the active sludge is exhausted to the
953 atmosphere through the air exhaust pipe 30.

954
955 **The processing apparatus having the two-staged processing vessel 1** has a feature that the size
956 thereof can be further reduced without lowering a processing capacity as compared with the
957 embodiment 1 provided with the single vessel. An example of waste processing actually carried
958 out by charging kitchen garbage to the processing apparatus of the embodiment 2 will be
959 specifically described in an embodiment 5.

960
961 Embodiment 3

962
963 FIG. 6 is a side view of a still another embodiment of the present invention in the state that an
964 outside box is removed in the same way as FIG. 2 of the embodiment 2.

965
966 **This apparatus has a feature such that a processing vessel 1** is supported by an independent
967 auxiliary frame 35 and other components such as a heat exchanger 6 and the like are mounted on a
968 main frame 36 so that the assembly of the components and the service and maintenance of the
969 apparatus can be easily carried out.

970
971 An **air intake pipe 4 and an air return pipe 5 are connected to the processing vessel 1** through
972 a pipe connecting means 34 so that they can be removed from the **processing vessel 1**.

973
974 The **processing vessel 1** is supported by the auxiliary frame 35 formed separatably from the main

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975 frame 36 by which the heat exchanger 6, an air supply means 7 and a deodorizing means 29 are
976 supported.

977
978 Rotary shafts 20, 20' of the upper stage 2 and lower stage 3 of the processing vessel 1, bearings
979 (not shown), a sprocket 37 and a chain 38 for connecting the upper and lower rotary shafts 20, 20'
980 and an insulation member (not shown) are connected to the auxiliary frame 35, a part 39 of the
981 outside box being also connected thereto.

982
983 Numeral 40 denotes a frame connecting means which is arranged such that the auxiliary frame 35
984 and the components connected thereto can be easily removed from the main frame when service,
985 maintenance and the like are carried out.

986
987 Embodiment 4

988
989 FIG. 7 is a front longitudinal cross sectional view of a processing vessel of a further embodiment
990 of the processing apparatus of the present invention, wherein the processing vessel is obtained by
991 improving the processing vessel 1 of the embodiment 2.

992
993 This apparatus has a feature such that an intermediate partition plate 41 is disposed in a processing
994 unit and that agitation arms 23 in the processing unit are inclined with respect to rotary shafts 20,
995 20'. With this arrangement, an agitation width is more increased so that matters to be processed
996 are prevented from staying on the bottom of the processing vessel and from sticking to the wall
997 surface of the vessel by being baked.

998
999 More specifically, the rotary shaft 20, 20' are provided with the upper stage processing vessel 2
000 and lower stage processing vessel 3, respectively in the same way as the embodiment 2 and the
001 plurality of agitation arms 23 are mounted on the rotary shafts 20, 20' with an inclining angle in
002 the range of 3.degree.-45.degree. with respect to the radial direction of the rotary shaft.

003
004 As described above, with the inclination of the agitation arms 23 in the processing unit, when the
005 rotary shafts 20, 20' rotate, an agitation width is increased in accordance with the degree of
006 inclination of the agitation arms, so that the agitation arms can carry out an agitating motion in a
007 range larger than that of vertical agitation arms and swing matters to be processed more
008 effectively.

009
010 Further, an intermediate partition 41 is provided with the upper processing vessel 2 or lower
011 processing vessel 3. **Although each one intermediate partition is provided with these vessels,**
012 a plurality of intermediate partitions may be provided at predetermined intervals, when necessary.
013 With this arrangement, when the waste in the processing vessel 1 becomes light in weight by the

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1014 reduction of the water, the waste moves beyond the partition plate 41 to thereby falls into the
1015 adjacent **vessel**. Thus, by setting the intermediate partition plate to have a proper level of height, it
1016 becomes possible to maintain the waste in the **processing vessel** 1 while the waste has a minimum
1017 water level necessary for the waste to be fermented, and to move the waste into the **adjacent**
1018 **vessel** beyond the partition plate 41 when the water contained in the waste is reduced to be less
1019 than the minimum water level, that is, it is possible to make the intermediate partition plate have a
1020 function for automatically adjusting water. In this embodiment, by setting the partition plate 41 to
1021 have a height of 0.75.times.l to 1.times.l wherein l is the rotation diameter of the agitation arms
1022 23, it becomes possible to make the the intermediate partition plate 41 have a function for
1023 automatically adjusting water.

1024
1025 Although the agitation arms 23 in the upper and lower stages are inclined in the same direction in
1026 this embodiment, they need not always be inclined in the same direction but may be inclined in
1027 any direction so long as the range in which the agitation arms 23 are moved can be substantially
1028 increased.

1029
1030 In any of the apparatuses of the embodiments 1-4, a rotating direction of the agitation arms 23,
1031 that is, a method of driving the rotary shaft 20 (20') can be selected from three rotation control
1032 sequences of, for example, (1) rotating the shaft continuously in a predetermined direction, (2)
1033 intermittently rotating the shaft with a predetermined stop period of time, and (3) rotating the shaft
1034 in a regular direction, stopping the shaft for a predetermined period of time and then rotating the
1035 shaft in another reverse direction, and the like. Further, as shown FIG. 16, when the agitation arms
1036 are mounted on the shaft in such a manner that the adjacent agitation arms 23 are continuously
1037 circumferentially dislocated each other (for example, at 30.degree.), the matters to be processed
1038 can be easily moved in an axial direction. Since the driving method (3) was particularly excellent
1039 when an experiment was carried out by the use of kitchen garbage generated from restaurants, the
1040 process example shown in the following embodiment 5 was carried out in accordance with this
1041 method (3).

1042 1043 Embodiment 5

1044
1045 Solid organic waste composed of kitchen garbage generated from restaurants was processed by the
1046 apparatus of the embodiment 2 shown in FIGS. 2-5, and the kitchen garbage was composed of
1047 50% of boiled rices, 10% of noodles, 20% of meat and fried food and 20% of vegetables and
1048 fruits on an average, and contained water of 70-75%. The waste was charged from the waste
1049 charge port 15 in an average amount of 16 kg a day and amounted to 325 kg in 20 days.

1050
1051 As environmental temperature conditions, an outside air temperature was 5.degree.-15.degree. C.
1052 and the inside of the **processing vessel**⁵ 1 was maintained to 55.degree.-65.degree. C. Further, the

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agitation arms 23 were rotated in a usual direction for 3 minutes, stopped for 3 minutes and then rotated in another reverse direction for 3 minutes by the drive means 22.

The processing vessel had an inside volume of 200 liters in the total of the upper and lower stages (the volume of the upper stage and that of the lower stage were divided to the ratio of 4:3). Prior to operation, total 50 kg of compost (aerobic bacteria) containing soil bacteria suitable for the temperature condition of about 60.degree. C. was uniformly placed as the species of bacteria 17 on the bottom surface of the **processing vessels** of the upper stage and lower stage.

The average of 3 kg of compost was discharged a day during the test period and 58 kg of compost in total was discharged in 20 days.

As a result of the above experiment, the resulting volume of the kitchen garbage was reduced to about one sixth the original volume thereof, a component decomposition ratio was 30-40% and further discharged matters had a low water content of 15% or less. Thus, it was confirmed that the resulting compost could be handled easily because it did not become musty and had a low level of a bad odor.

Further, with respect to deodorization, the deodorizing vessel 31 was filled with active sludge conventionally used for water treatment in a water purification plant and a gas generated in the **processing vessel 1** was supplied to the deodorizing vessel 31 and was deodorized under the same outside temperature condition during the same period, as the above. An amount of the gas to be supplied to the deodorizing vessel 31 was equal to the amount of air to be supplied (amount of fresh air to be taken in) to compensate the amount of oxygen consumed by fermentation. Further, it could be confirmed that a gas discharged into air had a very low level of a bad odor and a bad odor other than the odor intrinsic to the active sludge was not generated.

Embodiment 6

FIG. 8 is a front vertical cross sectional view of the main part of an embodiment 6 of the **processing apparatus** of the present invention, and FIG. 9 is a side cross sectional view of the processing apparatus. In this embodiment, the solid organic waste processing apparatus includes a solid organic matter processing device A and a gas and liquid processing device B.

The solid organic matter processing device A includes a processing vessel 150 having a charge port 151 opened through the upper portion thereof. The **processing vessel 150** has a box with a curved bottom surface 152 formed to the shape of substantially a Greek letter ".omega." which has a cross section formed by connecting two semicircular arcs in parallel and the curved bottom surface 152 is divided into a first curved bottom surface 521 and a second curved bottom

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1092 surface 522. Each of the first curved bottom surface 521 and second curved bottom surface 522 is
1093 formed to an arc having a center O and a radius r and a connecting point 525 where the first
1094 curved bottom surface 521 is connected to the second curved bottom surface 522 is located
1095 substantially at a height of $\frac{2}{3}$ of "r" from the lower portion of the bottom surface.

1096
1097 A plurality of electric band-shaped heaters 153 as a means for heating the **processing vessel** 150
1098 are attached around the outside wall of the curved bottom surface 152 formed to the Greek letter
1099 ".omega." shape. The bottom portion of the **processing vessel** 150 is maintained to a temperature
1100 of 60.degree. C.-80.degree. C. by the heater 153 at which waste contained therein can be
1101 effectively and sufficiently fermented.

1102
1103 The **processing vessel** 150 includes a crushing unit 110 continuous to the charge port 151 and a
1104 processing unit 120 adjacent to the crushing unit 110.

1105
1106 The crushing unit 110 has comb-shaped arms 112 fixed therein, these arms being disposed on the
1107 side surface of the **processing vessel** 150, and is separated from the processing unit 120 by a
1108 charge side partition 114. The charge side partition 114 hangs down from the upper surface of the
1109 **processing vessel** 150 and a gap 116 is formed between the partition 114 and the lower surface of
1110 the **processing vessel** 150. Further, the size of the gap 116 can be adjusted by arranging the
1111 partition 114 in such a manner that it can slide in the height direction thereof. Further, the charge
1112 side partition 114 has a hole 117 defined on the upper portion thereof through which air is
1113 communicated between the crushing unit 110 and the processing unit 120.

1114
1115 The processing unit 120 is provided with an end plate side partition 124 at the center thereof
1116 which is fixed to the bottom of the **vessel** and a gap is formed between the upper portion of the
1117 partition 124 and the inside wall of the **processing vessel** 150. An end plate 125 is disposed to an
1118 end of the processing unit 120 and an end plate 115 is disposed to the side surface of the crushing
1119 unit 110, respectively so that the opposite ends of the **processing vessel** 150 of the **solid organic**
1120 **matter processing device A are closed. An openable/closable lid is disposed to the waste**
1121 **charge port** 151.

1122
1123 Two rotary shafts 140, 145 extending through the crushing unit 110 and processing unit 120 are
1124 disposed in the **processing vessel** 150 by being supported by both end plates 115, 125 thereof, an
1125 end of each of the rotary shafts 140, 145 being connected to a drive unit 130. The first rotary shaft
1126 140 is located substantially at the center O of the curved bottom (semicircular shape) surface 521
1127 and the second rotary shaft 145 is located substantially at the center O of the curved bottom
1128 surface 522. Agitation arms 142 are radially fixed to the rotary shafts 140, 145 at predetermined
1129 intervals. The agitation arms of the first rotary shaft 140 and the agitation arms of the second
1130 rotary shaft 145 are disposed so that they do not interfere one another or interfere with the fixed

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arms 112 in the crushing unit 110. A plurality of the agitation arms 142 are disposed in the crushing unit 110 and the processing unit 120, respectively. The first rotary shaft 140 is coupled with the second rotary shaft 145 outside the **processing vessel** 150 through a sprocket and chain or a gear and they are also coupled with the drive unit 130 having a motor 133.

A discharge port is defined to the end plate 125 of the processing unit 120 and a discharge tube 155 is connected through the discharge port. The discharge tube 155 has a cylindrical shape and the lower end thereof is opened toward a storing unit 160. The storing unit 160 is disposed at an end of the gas and liquid processing device B disposed below the solid organic matter processing device A, and matters (compost) **processed in the processing vessel**⁶ 150 drop into the storing unit 160 through the discharge tube 155 and are deposited therein.

The gas and liquid processing device B is disposed below the solid organic matter processing device A through a frame 135.

The gas and liquid processing device B includes a heat exchanging unit 170, a deodorization processing unit 180, a water purification unit 190 and the storing unit 160.

The storing unit 160 is provided with an openable/closable discharge gate 163 formed to the wall surface thereof to take out processed matters accommodated therein and the discharge gate 163 is arranged as a portion of the outside wall of the gas and liquid processing device B.

The heat exchanging unit 170 includes a heat exchanger 172 and a blower 174. The heat exchanger 172 has a plurality of air pipes disposed in parallel and interconnected to each other.

The upstream side of the heat exchanger 172 is connected to a gas intake pipe 176 which is connected to the crushing unit 110 of the processing vessel⁷ 150, whereas the downstream end of the heat exchanger 172 is connected to the processing unit 120 through an air return pipe 178. A gas circulator 175 is disposed in the midway of the air return pipe 178 through which the heat exchanger 172 is connected to the processing unit 120. The gas circulator 175 serves to supply air in the direction of the processing unit 120. **When the gas circulator 175 is operated, the gas in the vessel is taken into the air pipes of the heat exchanger**⁸ 172 from the crushing unit 110 side through the gas intake pipe 176 and positively supplied and circulated to the processing unit 120 through the air return pipe 178. During this period, air containing vapor due to fermentation which is supplied from the crushing unit 110 and passes through the air pipes is **cooled by outside air of low temperature blown thereto by the blower**⁹ 174 disposed in the path of the air so that water (moisture) contained in the vapor is changed to water droplets. Then, the air from which water is removed is returned to the processing unit 120 through the air return pipe 178.

A deodorizing communication pipe 182 branched from the gas intake pipe 176 is disposed to a

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1170 portion of the path through which gas is circulated from the gas circulator 178 and connected to
1171 the deodorization processing unit 180.

1172
1173 The deodorization processing unit 180 includes a deodorizing vessel 184, a deodorizing blower
1174 186 disposed in the path of the deodorizing vessel communication pipe 182, and an exhaust pipe
1175 188 having an end opened through the upper portion of the deodorizing vessel 184 and the other
1176 end opened to the outside air. The deodorizing unit 184 is filled with liquid containing
1177 microorganisms for decomposing an odor. When the deodorizing blower 186 of the deodorizing
1178 unit 180 is operated, a gas containing an odor is introduced from the deodorizing communication
1179 pipe 182 into the deodorizing vessel 184 and aerated in the liquid so that the gas comes into
1180 contact with the microorganisms and so that the odor component in the gas is decomposed, then
1181 odorless air being exhausted to the outside of the apparatus through the exhaust pipe 188.

1182
1183 An amount of the air subjected to the deodorizing process and exhausted to the outside, that is, an
1184 amount of air transferred by the blower 186 is made to substantially correspond to the air
1185 consumed in the processing vessel 150 by fermentation, and this air is supplied through the
1186 clearance between the processing vessel 150 and the charge port 151, the clearance between the
1187 storing unit 160 and the discharge gate 163, and the like.

1188
1189 The liquid purification unit 190 includes a drain pipe 192 disposed downward of the heat
1190 exchange unit 170 to discharge water produced from vapor condensed by exchanging the heat
1191 thereof, an adjustment tank 194 and a processing tank 196 are connected to the drain pipe 192, the
1192 adjustment tank 194 being filled with a weak alkaline material 193 (limestone, lime) and a
1193 processing tank 196 being filled with a carrier 195 to which microorganisms are fixed, and further
1194 a water discharge pipe 198 opened to the outside of the apparatus is disposed behind the
1195 processing tank 196. The carrier 195 to which the microorganisms (bacteria) are fixed is
1196 composed of polyvinyl alcohol (PVA) formed to a body having a number of honeycomb-shaped
1197 holes in which aquatic bacteria are contained. Since a reaction caused by the fermentation in the
1198 processing unit 120 is accompanied with weak acid such as fatty acid, acetic acid etc., water
1199 changed to water droplets by the heat exchange unit 170 exhibits weak acidity. This acid water is
1200 neutralized by the weak alkaline material 193 filled in the adjustment tank 194. Further, although
1201 some organic matters float in the water made to droplets, they are decomposed in the processing
1202 tank 196 disposed downward of adjustment tank 194 and filled with the carrier 195 to which the
1203 microorganisms are fixed and thus liquid which is neutralized and from which the organic
1204 materials are removed is discharged from the discharge pipe 198.

1205
1206 Each of the adjustment tank 194 and processing tank 196 of the liquid purification unit 190
1207 disposed in the gas and liquid processing device B is formed to have a shape of a pipe at least one
1208 end of which can be opened and closed in order not to lower the space efficiency of the respective

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Why the Crockett invention is a significant improvement upon prior art; our system does NOT require that the compost be in any form of vessel, container or enclosure of any sort:

components disposed in the gas and liquid processing device B. With the openable/closable arrangement of the one end of the tanks or the pipes, the pipes can be easily filled with the weak alkaline material 193 and carrier 195 to which the microorganisms are fixed and further since these tanks are made of the pipes, they can be also effectively mounted to the apparatus from a view point of mounting space.

Next, an operation mechanism of the solid organic waste processing apparatus will be described. Species of bacteria 100 for fermentation are previously put on the curved bottom portion 152 of the processing vessel 150. The species of bacteria are, for example, species of aerobic bacteria and the like collected from compost, and the like. First, the drive unit 130 is driven to rotate the rotary shafts 20, 20' and kitchen garbage as a matters to be processed is charged from the charge port 151. Solid matters are crushed between the fixed arms 112 and the agitation arms 142 in the crushing unit 110 and oxygen is supplied into the kitchen garbage scooped up by the agitation arms 142. At this time, since the connecting portion 525 where the first curved bottom surface 521 is connected to the second curved bottom surface 522 has the height of $\frac{2}{3}$ of r and the agitation arms 142 pass through the connecting portion 252 in an inclined state, the matters agitated by the agitation arms 142 are free to move between the first curved bottom surface 521 and the second curved bottom surface 522 and thus the agitation, mixing and crushing of the matters are promoted. The matters to be processed made to a mud state sequentially flow into the processing unit 120 through the gap 116 below the partition 114.

In the processing unit 120, the crushed organic matters to be processed are further agitated by the agitation arms 142 and uniformly mixed with the specimens of bacteria 100. Aerobic bacteria ferment and decompose the matters to be processed. At this time, the heater 153 disposed around the outside surface of the bottom portion is controlled by the thermostat (not shown) so that it is maintained at a suitable temperature of 50.degree.-80.degree. C. to thereby assist the promotion of the fermentation and decomposition of the matters to be processed in the processing vessel¹⁰ 150. Since the specimens of bacteria proliferate by themselves by eating organic waste, they are needed only when the operation of the apparatus starts for the first time and need not be supplemented while the apparatus is in operation because aerobic bacteria always exist and serve as specimens of bacteria to be charged next time.

In addition, when next kitchen garbage is charged from the charge port 151, it overflows and overflowed garbage flows into the next region through the gap above the charge side partition 114 and the gap below the end plate side partition 124. The water (moisture) contained in the matters to be processed which have moved downward of the processing vessel 150 is evaporated and the matters are made to powder compost. When a predetermined amount of the processed matters (compost) are stored in the processing vessel 150, the compost drops into the storing unit 160 from the end plate 125 and recovered from the discharge gate 163.

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A gas containing water generated in the **processing vessel** 150 when the garbage ferments is processed by the gas and liquid processing device B. **The gas of high temperature and high humidity (mainly composed of air accompanied with a bad odor and vapor) is taken into the high temperature side (upstream side) of the heat exchanger 172 from the crushing unit** 110 through the gas intake pipe 176 by the operation of the gas circulator and flows through the air pipes. While passing through the heat exchanger 172, the vapor in the gas is condensed to water by exchanging the heat thereof with air supplied by the blower 174 and the water is discharged from the low temperature side (downward side) of the heat exchanger 172 through the drain pipe 192. On the other side, the air from which the water is removed is returned into the processing vessel 150 through the air return pipe 178 and absorbs again the water (moisture) in the **processing vessel** 150. Water dropped from the drain pipe 192 is supplied to the adjustment tank 194 and neutralized by the weak alkaline material (limestone, lime) and further the organic matter contained in the water is decomposed by the microorganisms 195 in the processing tank 196. Thus, the water is made harmless and discharged from the discharge pipe 198 to the outside of the apparatus.

Further, a gas flowing downward through the gas intake pipe 176 of the gas circulation path is partly supplied to the deodorizing communication pipe 182 branched from the pipe 176. The gas is blown into the deodorizing vessel and the bad odor of the gas is decomposed by coming into contact with the microorganisms in the vessel and exhausted from the exhaust pipe 188 to the outside of the apparatus as odorless air. Since the pressure of air in the **processing vessel** 150 is reduced in proportion to an amount of the exhausted air, air is supplied through the clearance between the **processing vessel** 150 and the charge gate of the charge port 151, the clearance between the storing unit 160 and the discharge gate 163 and the like. **Therefore, the inside of the circulation system of the apparatus is maintained substantially near to the atmospheric pressure as a whole.**¹¹

Since the connecting portion 525 where the first curved bottom surface 521 of the **processing vessel** 150 is connected to the second curved bottom portion 522 thereof is located below the rotary shafts, the size W of the processing vessel 150 in the direction perpendicular to the rotary shafts can be reduced. Thus, the apparatus can be made small in size as a whole. Further, since a large amount of waste can be simultaneously agitated and mixed by the two rotary shafts 140, 15, a processing efficiency can be improved with an increased processing speed.

Since this apparatus is arranged to have a relatively small size and since waste can be continuously charged to the apparatus, the apparatus can be easily operated and maintained. When it is applied to the industrial fields where kitchen garbage is generated, the apparatus can process waste without depending upon waste collectors and thus the waste can be economically processed. Further, since a gas and liquid discharged to the outside of the apparatus are harmless and

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odorless, surroundings are not adversely affected by them.

Since the species of bacteria 100 prepared first proliferate by themselves by eating kitchen garbage (solid organic waste), they are needed only when the operation of the apparatus starts for the first time and need not be supplemented while the apparatus is in operation because the aerobic bacteria always exist and serve as specimens of bacteria to be charged next time.

Further, since water generated when solid organic waste ferments is removed by the heat exchanger 170 and since condensed water is purified and discharged to the outside of the apparatus, recovered compost is dry and almost odorless powder even if a conventionally used water content adjustment material such as sawdust, rice hulls and the like is not charged to absorb water. Therefore, the compost can be recovered as manure with a very high added value for raising farm products, garden plants and other general plants and this apparatus is preferable from the view point of the reuse of waste.

Embodiment 7

This embodiment is arranged such that the deodorization processing mechanism of a gas and liquid processing device B also serves to remove an organic matter contained in water to be discharged. The arrangement of this embodiment will be described with reference to a cross sectional view of the main part of the gas and liquid processing device of this embodiment shown in FIG. 11.

Since a solid organic waste processing device is the same as that described with reference to the embodiment 6, the description thereof is omitted.

The gas and liquid processing device is provided with a heat exchange unit 700 similar to that of the embodiment 6. An adjustment tank 940 is connected to a drain pipe 920 located downward of the heat exchange unit 700. The adjustment tank 940 is filled with a weak alkaline material 980 (limestone, lime). A deodorization processing unit 180 has a deodorizing communication pipe 820 branched from a part of a gas circulation path and the deodorizing communication pipe 820 is opened in the lower portion of a deodorizing vessel 840. The deodorizing vessel 840 is filled with a carrier 850 to which microorganisms are fixed, the carrier being similar to that used in the embodiment 6, and an odor is decomposed by the microorganisms.

Further, a water level tank 870 is disposed in the vicinity of the deodorizing vessel 840 which is communicated with the water level tank 870 through a coupling pipe 855 disposed at the lower portion thereof. Further, a water discharge pipe 880 is attached to the water level tank 870 at the position thereof which is as high as the water level in the deodorizing vessel 840 and opened to the outside of the apparatus. Since the water discharge pipe 880 of the water level tank 870 is

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1327 located at the water level of the deodorizing vessel 840, the water level in the deodorizing vessel
1328 870 is not changed so that the carrier 850 is in good contact with a gas to be aerated which is
1329 supplied from the deodorizing communication pipe 820 at all times.

1330
1331 A dropping pipe 950 coupled with the adjustment tank 940 is opened through the upper portion of
1332 the deodorizing vessel 840 to drop water passing through the adjustment tank 940 into the
1333 deodorizing vessel 840. The organic matter in the water flowing into the deodorizing vessel 840 is
1334 decomposed and removed by the microorganisms of the carrier 850.

1335
1336 The gas and liquid processing device arranged as described above takes a gas containing vapor
1337 into the pipe of the heat exchanger 700, **cools the gas by outside air blown thereto and changes**
1338 **the water contained in the gas to droplets**¹² while returning the air from which water is removed
1339 into the solid organic matter processing device. The water produced by condensing the vapor by
1340 exchanging the heat thereof is supplied to the adjustment tank 940 filled with the weak alkaline
1341 material 930 (limestone, lime) through the drain pipe 920, neutralized by the weak alkaline
1342 material 930 and stored in the deodorizing tank 840 through the dropping pipe 950. Further, a gas
1343 containing an odor and supplied from the deodorizing communication pipe 820 by a deodorizing
1344 blower 860 comes into contact with the carrier 850 which has the microorganisms fixed thereto
1345 and which is filled in the deodorizing vessel 840, by being aerated in the liquid of the deodorizing
1346 tank 840. As a result, the odor component of the gas is decomposed and the gas is made to
1347 odorless air and at the same time some organic matters contained in the water discharged through
1348 the adjustment tank 940 are decomposed by the carrier 850 which has the microorganisms fixed
1349 thereto and which is filled in the deodorizing vessel 840. Then, the water in the deodorizing vessel
1350 840 is transferred to the level adjustment tank 870 by an amount corresponding to the water
1351 supplied into the deodorizing vessel 840 and the water overflowing the position where the water
1352 discharge pipe 880 is attached to the water level tank 870 is discharged to the outside of the
1353 apparatus.

1354
1355 As described above, since the solid organic waste processing apparatus shown in this embodiment
1356 can deodorize a gas while decomposing the organic matters contained in water to be discharged
1357 by the deodorizing processing means (deodorizing vessel) 840 at the same time, the arrangement
1358 of the apparatus can be simplified, and thus a gas can be deodorized and liquid can be purified by
1359 a small apparatus.

1360 Embodiment 8

1361
1362 This embodiment shows a solid organic waste processing apparatus by which **the processing**
1363 **vessel of a solid organic matter processing unit A** is more strongly disposed. The arrangement
1364 of the **processing vessel** will be described with reference to a cross sectional view of the main
1365

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part of the solid organic matter processing unit A shown in FIG. 12.

The **processing vessel** 500 has opposite side walls 520, 530 which are fixed through bolts 370 to side angle steels 360 secured to the frame 350 of the solid organic waste processing apparatus. Further, the portion where a first curved bottom surface 551 is combined with a second curved bottom surface 552 is supported by a bottom angle steel 380 secured to the frame 350, the above combining portion being located below the connecting portion 555 where the first portion 551 is connected to the second portion 552. The bottom angle steel 380 is secured to the curved bottom surfaces 551, 552 through bolts.

These side angle steels 360 and bottom angle steels 380 support the weight of the **processing vessel** 500 as a whole and prevent force from concentrating onto the first curved bottom surface 551 and second curved bottom portion 552 so that the cross sectional structures thereof are not deformed and so that the agitation arms fixed to two rotary shafts are prevented from coming into contact one another by the deformation of the semicircular inside wall of **the vessels** having the first and second curved bottom surfaces 551 and 552. The same effect can be obtained even if the **processing vessel** is supported by channel steels in place of the angle steels.

Embodiment 9

This embodiment shows a solid organic waste processing apparatus which is suitably installed to regions having a less amount of rain or having insufficient water, deserts, and the like. FIG. 13 is a diagram explaining an arrangement of the processing unit of the solid organic waste processing apparatus of this embodiment, wherein the solid organic waste processing apparatus 200 is arranged separately from a compost storing apparatus 250.

A solid organic matter processing device A and a gas and liquid processing device B which have the same arrangement as those of the embodiment 1 are disposed in the solid organic waste processing apparatus 200.

The compost storing apparatus 250 in which compost is deposited and stored is disposed adjacent to the solid organic waste processing apparatus 200. The solid organic matter processing device A of the solid organic waste processing apparatus 200 is connected to the compost storing apparatus 250 through a compost discharge pipe 240, and a blower 245 is disposed in the transfer path of the compost discharge pipe 240 to promote the transfer of the compost.

Further, a water storage tank 270 is disposed adjacent to the solid organic waste processing apparatus 200 and a discharge pipe 260 is opened toward the water storage tank 270 so that water from the gas and liquid processing device B of the solid organic waste processing apparatus 200 is

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1405 supplied dropwise to the tank 270. Further, a water supply pipe 280 connected to an irrigation unit
1406 290 having a sprinkling mechanism is connected to the water storage tank 270 through a pump
1407 275.

1408
1409 With this arrangement, compost discharged from the solid organic matter processing device A of
1410 the solid organic waste processing apparatus 200 is discharged into the compost storing apparatus
1411 250 through the compost discharge pipe 240. The compost deposited in the compost storing
1412 apparatus 250 is transported by a truck 220 and spread over farms requiring manure.

1413
1414 Water discharged from the gas and liquid processing device B is stored in the water storage tank
1415 270 through the discharge pipe 260. Then, water pumped up by the pump 275 is sprinkled by the
1416 irrigation unit 290 through the water supply pipe 280 to the surroundings to irrigate dry soil in the
1417 surroundings.

1418
1419 When solid organic waste (kitchen garbage) is directly spread over wasteland or sandy land, since
1420 it generates heat by being rotten and fermented in soil and further takes oxygen from the roots of
1421 plants, the plants are made to a so-called root-rotted state and become difficult to be raised. When
1422 the solid organic waste processing apparatus 200 is combined with the irrigation unit 290 and the
1423 like and compost which is dried and made to powder is spread over wasteland, however, the
1424 wasteland can be made rich as well as when water, which is said to be contained in kitchen
1425 garbage in an amount of 80 wt %, is purified to an odorless and harmless state and sprinkled to
1426 dry land, the wasteland and sandy land can be planted with trees, whereby nature can be prevented
1427 from being destroyed by dumped kitchen garbage and environmental safeguards and planting of
1428 trees can be promoted.

1429
1430 Embodiment 10

1431
1432 A feature of an embodiment 10 shown in FIG. 14 is that the function of the water level tank 870
1433 and the function of the adjustment tank 940 in the embodiment 7 (FIG. 11) is carried out by a
1434 single adjustment tank 1010. Since the other arrangement of the embodiment 10 is the same as
1435 that of the embodiment 7, only the arrangement relating to the adjustment tank 1010 will be
1436 described.

1437
1438 The adjustment tank 1010 is connected to a drain pipe 920 and filled with a weak alkaline
1439 material 980 (limestone etc.). An end of the drain pipe 920 is connected to the bottom of the
1440 adjustment tank 1010 to introduce water generated in a heat exchanger into the adjustment tank
1441 1010. A deodorizing vessel 1020 (in which a carrier 850 containing microorganisms is
1442 accommodated in the same way as the embodiment 7) is disposed adjacent to the adjustment tank
1443 1010 and the upper portion of the adjustment tank 1010 is connected to the bottom portion of the
1444 deodorizing vessel 1020 through a communication pipe 1030 so that water supplied from the

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adjustment tank 1010 to the deodorizing vessel 1020 is purified by the microorganisms in the deodorizing vessel 1020. A water discharge pipe is attached to the upper portion of deodorizing vessel 1020 to discharge the purified water exceeding a predetermined amount. An end of a deodorizing communication pipe 820 having the same function as that of the embodiment 7 is disposed to the bottom of the deodorizing vessel 1020 and an exhaust pipe 1050 is attached to the upper portion of the deodorizing vessel 1020 so that a gas supplied from the deodorizing communication pipe 820 into the deodorizing vessel 1020 and deodorized therein is exhausted through the exhaust pipe 1050.

Operation of this embodiment 10 will be described below. Water generated in the heat exchanger and containing an organic matter is supplied into the adjustment tank 1010 and neutralized by the weak alkaline material 980 (limestone etc.) and the neutralized water is introduced to the bottom of the deodorizing vessel 1020 through the communication pipe 1030 and discharged from the discharge pipe 1040 with the organic material thereof removed in the deodorizing vessel 1020 by the action of the microorganisms contained therein. Further, a gas containing a bad odor and supplied from the deodorizing communication pipe 820 is also deodorized by the action of the microorganisms in the deodorizing vessel 1020 and exhausted from the exhaust pipe 1050.

Embodiment 11

An embodiment 11 shown in FIG. 15 is arranged such that one end of a separate air return pipe 1100 is connected to the pipe disposed downward of the pump 33 with another end of the pipe 1100 being opened to the crushing unit 1a having the same structure as in the embodiment 1 so that a part of air exhausted by the pump 33 is supplied to the crushing unit 1a through the air return pipe 1100 to thereby promote dehydration in the crushing unit 1a. The other arrangement of the embodiment 11 is the same as that of the embodiment 1.

As described above, expected objects can be achieved by the present invention. More specifically, there can be provided the solid organic waste processing apparatus which does not scatter a bad odor and a lot of vapor to the surroundings, does not need the addition of sawdust, rice hulls etc. as a water content adjustment material and is capable of being charged with kitchen garbage at any time and capable of decomposing the garbage at a high decomposing ratio at a high speed.

Further, there can be provided the small solid organic waste processing apparatus which can be installed in a very small space when installed in the kitchen and the like of restaurants.

Furthermore, since recovered compost can be effectively utilized as manure for growing plants and since kitchen garbage can be recovered and reused as a matter having a value, the present invention can greatly contribute to industries from the view point of environmental safeguards. Further, in the present invention, both of the heat exchanger and the circulation constitution comprising the air-taking-out pipe and the air-return pipe act to realize at the same time both

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1485 respects, which apparently contradict each other, that the water is removed for reducing the weight
1486 of matter to be processed and that the moisture in the processing vessel is maintained in such a
1487 necessary level as the sufficient fermentation can occur by the action of the aerobic bacteria, with
1488 the result that the apparatus of the present invention brings about a condition appropriate for the
1489 aerobic bacteria to act for the sufficient fermentation of the waste.

1490
1491 This apparatus has the simplified driving mechanism, and since bacteria for assisting fermentation
1492 proliferate by themselves by eating an organic matter while the apparatus is in operation,
1493 specimens of bacteria only need be supplied at the start of the apparatus for the first time and they
1494 need not be supplemented. Thus, the apparatus can be easily operated and maintained. When this
1495 apparatus is applied to industrial fields such as food processing industry, food service industry and
1496 the like where kitchen garbage is generated at all times, the apparatus can process waste without
1497 depending upon waste collectors and thus the waste can be economically processed. Further, since
1498 a gas and liquid discharged to the outside of the apparatus is harmless and odorless and
1499 surroundings are not adversely affected by them, the apparatus may be installed in the vicinity of
1500 the location where waste is generated and the waste can be dumped by being made to compost and
1501 water.

1502
1503 Further, since water generated when solid organic waste is fermented is removed by the heat
1504 exchanger, purified and discharged to the outside of the apparatus, even if a conventionally used
1505 water content adjustment material such as sawdust, rice hulls etc, is not charged to absorb water,
1506 compost is almost odorless dry powder with a very high added value and can be recovered as
1507 manure for growing farm products, garden plants, other general plants and this apparatus is
1508 preferable from the view point of the reuse of waste. Further, since dry air from which water is
1509 removed is returned to the processing vessel, matters to be processed are quickly dried.

1510
1511 Further, when kitchen garbage is directly dumped into the ground, the growing of plants is apt to
1512 be destroyed due to the heat generated when an organic matter ferments and due to the
1513 consumption of oxygen needed by the fermentation thereof, that is there is such a fear that nature
1514 is destroyed. However, the combination of the apparatus by which dry compost and pollution-free
1515 water can be created, the sprinkling means and the compost storing means contributes to plant arid
1516 regions, poor ground and the like with trees.

1517
1518
1519 * * * * *

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- 524
1. Lines #424-425: It is Significant that here they say the heat exchanger is for **condensing the water vapor in the composting air and make no mention of capturing heat for use outside of the composting process.**
 2. Lines #474-481, Here they explain the reason for their heat exchanger, **to remove excess water**, which becomes water vapor in the air being moved through the compost. **Their purpose of the heat exchanger seems to be to remove excess water, so that they can compost without using a lot of "bulking agent" which would tie up system capacity.**
 3. Lines #495-497 state: **"a heat exchanger disposed outside the solid organic matter processing device for condensing vapor in a gas supplied from the processing vessel of the solid organic matter processing device"** with no claim or mention of any attempt to use that heat for any purpose outside of the composting system. Nor is there any suggestion or claim that they can capture heat from compost that is not in a vessel.
 4. Lines #802-803: There is no suggestion here that the heat is being captured for use outside of the system, such as to heat greenhouses, buildings, or anything outside of the composting system.
 5. Lines #1052-1053: Here, again, they imply that the heat from the heat exchanger is being used to heat the compost, and no mention is made of any attempt to capture heat from the composting process for use outside of the composting process.
 6. in line #1141: Here they state that the compost is processed in the **processing vessel**. The Crockett process does not require any vessel, having the cost advantage of not requiring any form of vessel or container for the composting material.
 7. in line #'s 1156 & 1157: Here they are saying that the heat exchanger is connected to "crushing unit" and "processing unit", both units having been defined as parts of the **processing vessel**. There is no mention of their being able to get hot off-gas without a vessel or container.
 8. Lines 1161 & 1162 state that the gas going to the heat exchanger is coming from the **processing vessel**. Further they state that the cooling of the heat exchanger is from outside air of lower temperature, with no mention of capturing that heat for beneficial use outside of the composting system. There is some mention elsewhere that they use some of that heat to heat the composting unit, to maintain temperature of the composting mass in the range of 50° - 80°C.

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9. Ref: Lines 1165-1166: No mention is made of using the heat from the heat exchanger, outside of the composting system; no mention of using that heat to heat greenhouses, other buildings, or for any other beneficial use, other than to heat compost within their composting vessel.
10. Line #1236 states: **"matters to be processed in the processing vessel"**, showing that their invention is vessel dependant, and makes no mention or suggestion that they can get heat from compost that is not in a vessel or container. The Crockett process does not require that the compost be in any kind of vessel or container, and is therefore novel, and a major improvement as far as being able to capture Surplus Microbial Metabolic Heat for use outside of the composting system, such as using the Surplus Microbial Metabolic Heat for heating greenhouses, other buildings, and any other purpose for which heat is needed.
11. Ref: Lines 1273-1275: They state: **"Therefore, the inside of the circulation system of the apparatus is maintained substantially near to the atmospheric pressure as a whole."** This further suggests that they are not using "negative pressure" forced aeration. It is the use of "negative pressure" forced aeration that enables the Crockett invention to capture the heat from the air being pulled through compost that is on a composting pad **without the use of any vessel or container.**
12. Lines 1339-1340 make no mention of any attempt to use the heat from the heat exchanger for any beneficial use outside of the composting system.